# Perennial Stream Culvert Requirements:  Design and Delivery Strategies

July 28, 2021

Georgia Department of Transportation

# Today’s Topics and Presenters

- Ecological perspective
  - Dave Hedeen
    Ecology Section Manager
- Design perspective
  - Sam Woods, PE
    Assistant State Roadway Design Engineer
- Q&A moderator
  - Christina Schmidt
    Atkins Senior Scientist

# Housekeeping

- “Anonymous” attendees will not show up on the engagement report
  - ✓ Joiners via the **application** are signed into Teams so name will be recorded
  - ✓ Joiners via the **web** will be prompted to add name or join anonymously – please add your name
- Microphones are muted
- Questions via the moderated Q&A box
- Questions will be fielded after presentations
- Type in questions at anytime, no need to wait

# Recording

- Session is being recorded
  - ✓ Will be posted on GDOT's Recent Training webpage
- Two (2) PDH/CEU's available for those attending the live session this morning
- Email Gail D'Avino (gdavino@dot.ga.gov) to request a certificate by Friday July 30 – include
  - ✓ Name as you would like it to appear
  - ✓ Name of your employer

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# Training Objectives

- Following attendance at this session, project managers, designers and environmental staff will understand:
  - USACE’s Regional Conditions on perennial stream culverts
  - The concept of bankfull width: definition, methodology, relevance to design
  - Project delivery implications for projects with perennial stream culverts
  - How to design a culvert that complies with the Regional Conditions
  - How to address perennial stream culvert requirements, including diagrams, in Section 404 permit applications

# Perennial Stream Culverts: Design & Delivery Strategies

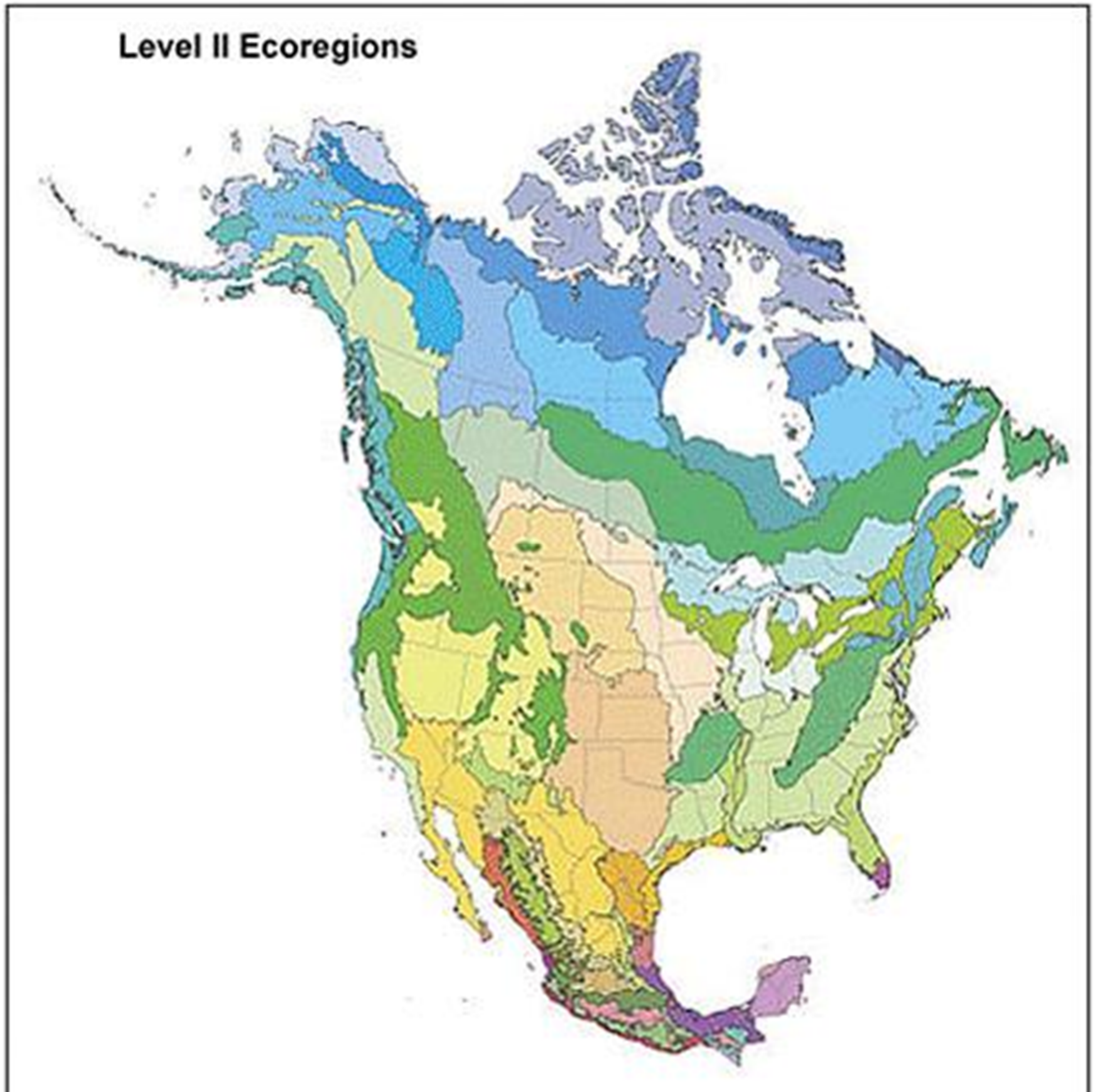
July 28th, 2021

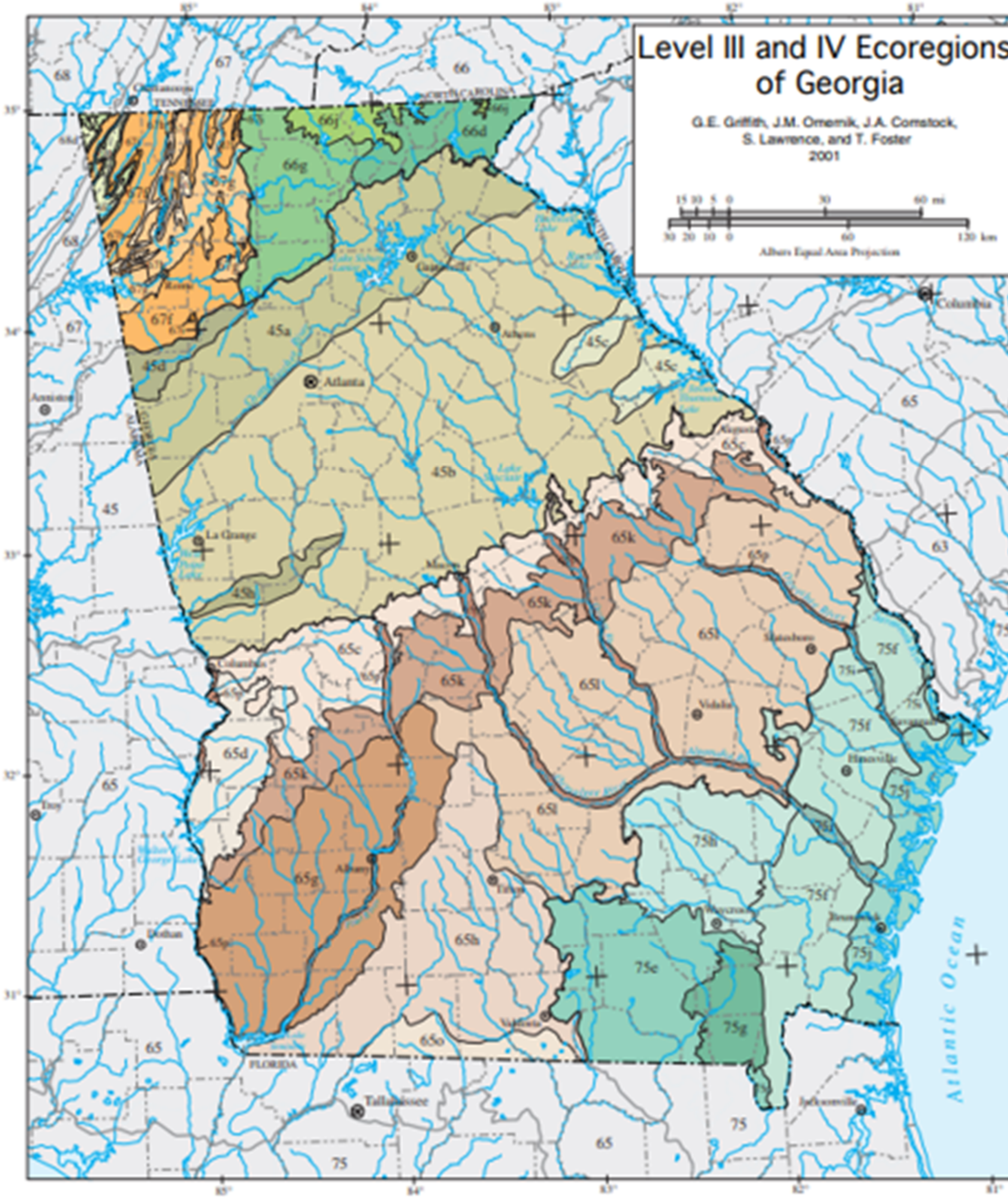

## Dave Hedeen

Ecology Section Manager


Plan Development Process

3/10/2021
Revision 3.3
Atlanta, GA 30308

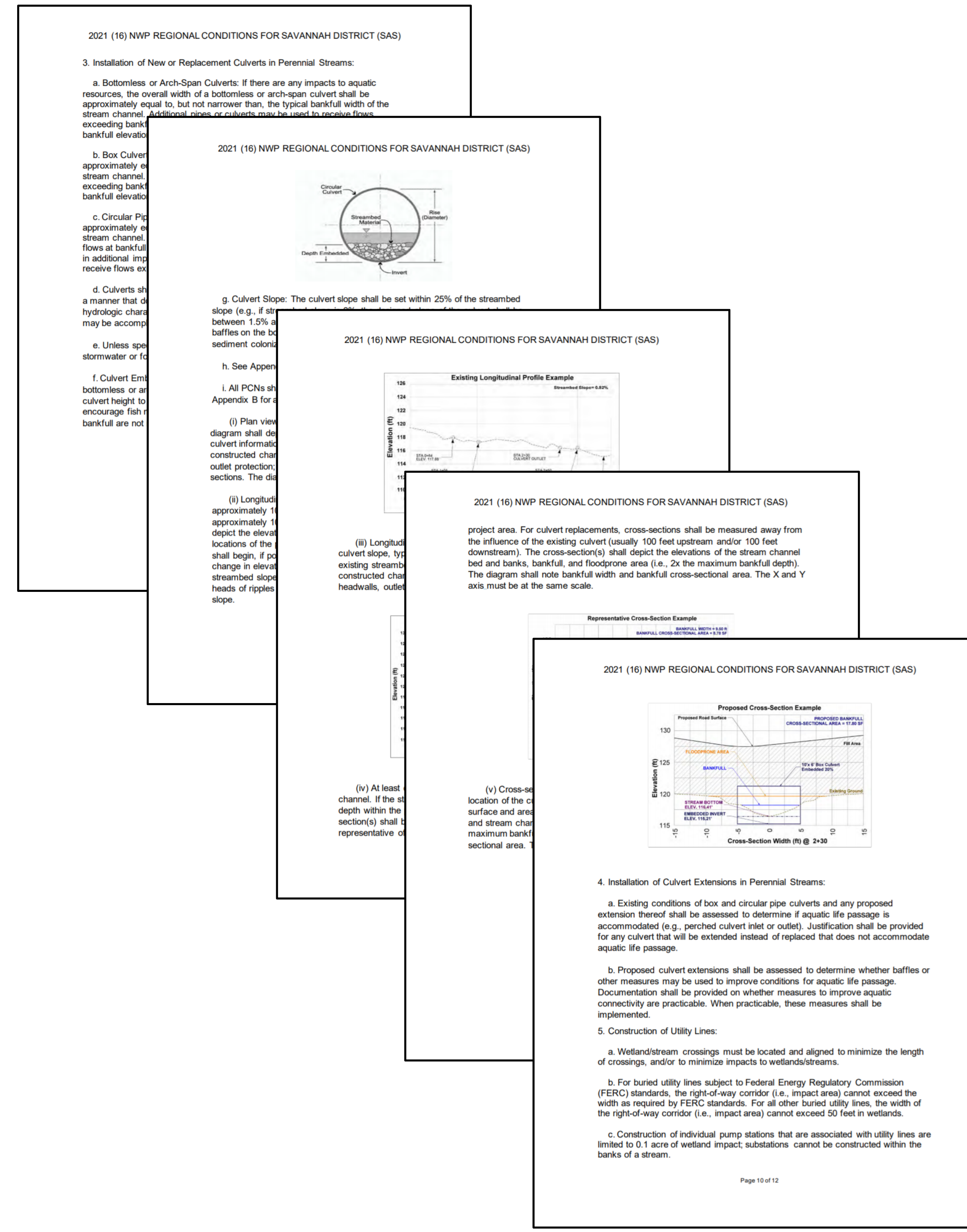

Level II Ecoregions


Level III and IV Ecoregions of Georgia
G.E. Griffith, J.M. Omernik, J.A. Comstock, S. Lawrence, and T. Foster
2001
Atlantic Ocean


10/31/2007

# USACE Culvert Conditions 2021

- Final 2021 Savannah District Regional Conditions for NWPs published March 8, 2021
  - Found under Public Notices
  - Per USACE's direction, Culvert Conditions (pages 6 – 10) should be applied to NWPs, RPs, and IPs


2021 (16) NWP REGIONAL CONDITIONS FOR SAVANNAH DISTRICT (SAS)

Proposed Cross-Section Example

4. Installation of Culvert Extensions in Perennial Streams:

a. Existing conditions of box and circular pipe culverts and any proposed extension thereof shall be assessed to determine if aquatic life passage is accommodated (e.g., perched culvert inlet or outlet). Justification shall be provided for any culvert that will be extended instead of replaced that does not accommodate aquatic life passage.

b. Proposed culvert extensions shall be assessed to determine whether baffles or other measures may be used to improve conditions for aquatic life passage. Documentation shall be provided on whether measures to improve aquatic connectivity are practicable. When practicable, these measures shall be implemented.

5. Construction of Utility Lines:

a. Wetland/stream crossings must be located and aligned to minimize the length of crossings, and/or to minimize impacts to wetlands/streams.

b. For buried utility lines subject to Federal Energy Regulatory Commission (FERC) standards, the right-of-way corridor (i.e., impact area) cannot exceed the width as required by FERC standards. For all other buried utility lines, the width of the right-of-way corridor (i.e., impact area) cannot exceed 50 feet in wetlands.

c. Construction of individual pump stations that are associated with utility lines are limited to 0.1 acre of wetland impact; substations cannot be constructed within the banks of a stream.

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MAR 2021

## Final 2021 Savannah District Regional Conditions for NWPs

**Expiration date: 3/14/2026**

SUBJECT: Final 2021 NWP Regional Conditions for 16 Nationwide Permits in Savannah District (SAS), going into effect March 15, 2021 and expiring on March 14, 2026.

**Public Notice and Attachments**

# Revised Culvert Conditions (2021)

**Installation of New or Replacement Culverts in Perennial Streams**:

1. Culvert Size:

   a. **Bottomless or Arch-Span Culverts:** If there are any impacts to aquatic resources, the overall width of a bottomless or arch-span culvert shall be approximately equal to, but not narrower than, the typical bankfull width of the stream channel. Additional pipes or culverts may be used to receive flows exceeding bankfull but the inlet(s) shall be baffled to or sit at the stream's bankfull elevation.

   b. **Box Culverts:** The overall width of a single or multi-barrel box culvert shall be approximately equal to, but not narrower than, the typical bankfull width of the stream channel. Additional pipes or culverts may be used to receive flows exceeding bankfull but the inlet(s) shall be baffled to or sit at the stream's bankfull elevation.

   c. **Circular Pipes/Culverts:** The overall width of a circular pipe/culvert shall be approximately equal to, but not narrower than, the typical bankfull width of the stream channel. Multiple circular pipes/culverts may not be used to accommodate flows at bankfull width except in scenarios where a culvert replacement would result in additional impacts to waters. Additional circular pipes/culverts may be used to receive flows exceeding bankfull but shall sit at the stream's bankfull elevation.

   d. Culverts shall be of adequate size to accommodate flows exceeding bankfull in a manner that does not cause flooding of associated uplands or disruption of hydrologic characteristics that support aquatic sites on either side of the culvert. This may be accomplished by installation of equalizer culverts in the floodplain.

   e. Unless specifically described in the PCN, use of undersized culverts to detain storm water or for pollutant treatment is not authorized.



- Developed collaboratively
- Improved organization/clarity of conditions
- Separated new/replacement culverts from culvert extensions
- Updated diagram requirements and examples
- Applicable to NWPs, RPs, IPs
- GDOT guidance forthcoming
- Implementation is the key!

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## New & Replacement Culverts

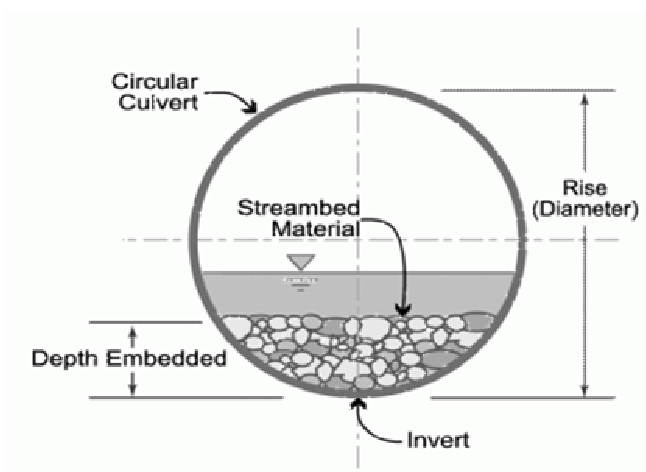
A. Conditions

1. **Culvert Size**
2. Culvert Embedding
3. Culvert Slope

# Revised Culvert Conditions (2021)

2. Culvert Embedding:

The upstream and downstream invert of culverts (except bottomless or arch-span culverts) shall be buried/embedded to a depth of 20% of the culvert height to allow natural substrate to colonize the structure's bottom and encourage fish movement. Additional culverts used to receive flows exceeding bankfull are not required to be embedded.




## New & Replacement Culverts

A. Conditions
   1. Culvert Size
   2. **Culvert Embedding**
   3. Culvert Slope

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# Revised Culvert Conditions (2021)

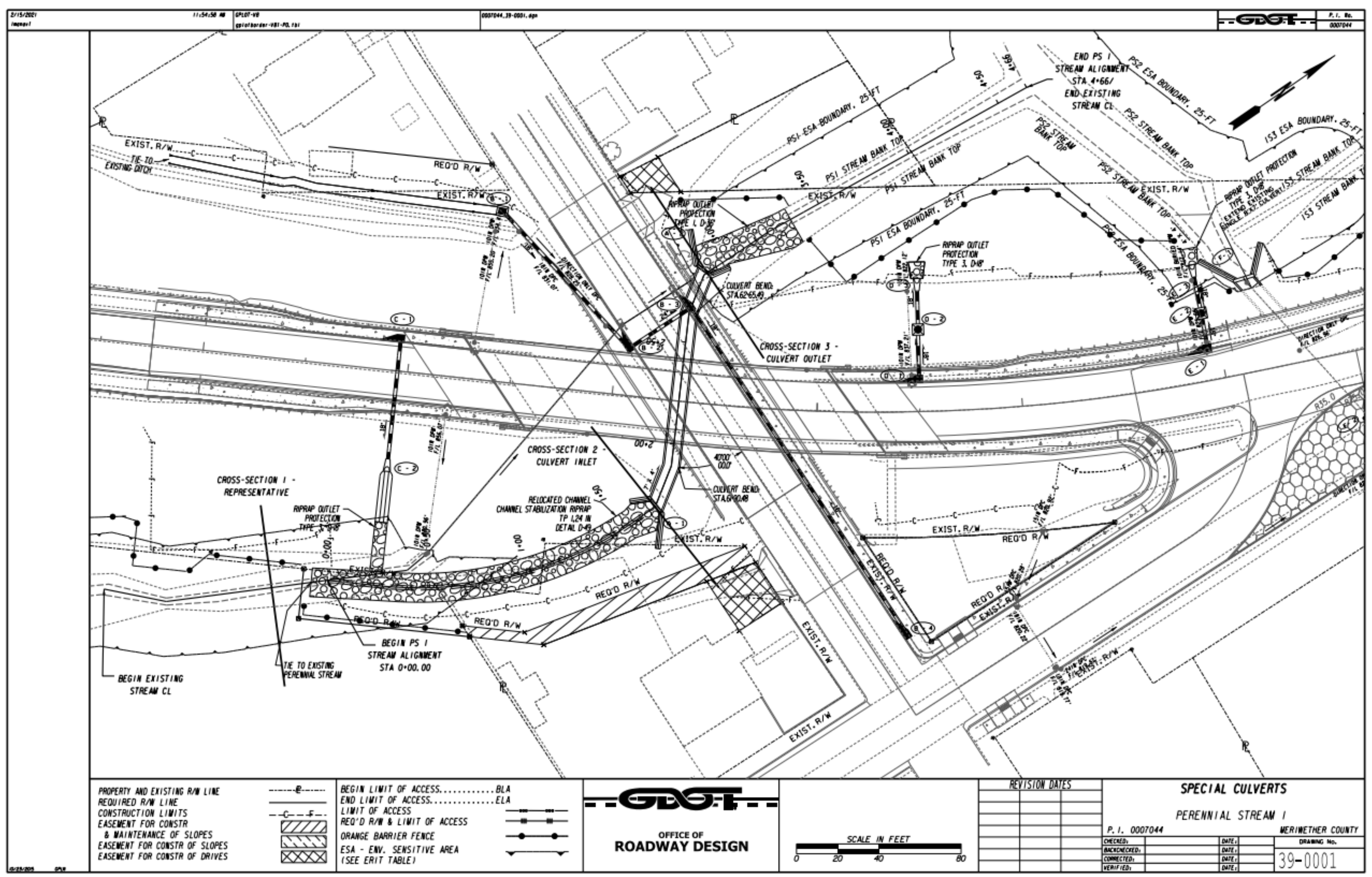
3. Culvert Slope:

The culvert slope shall be set within 25% of the streambed slope (e.g., if streambed slope is 2%, the designed slope of the culvert shall be between 1.5% and 2.5%). In situations where culvert slope exceeds 4%, interior baffles on the bottom of the culvert or other measures shall be used to allow for sediment colonization and/or velocity attenuation.

## New & Replacement Culverts

A. Conditions
1. Culvert Size
2. Culvert Embedding
3. **Culvert Slope**

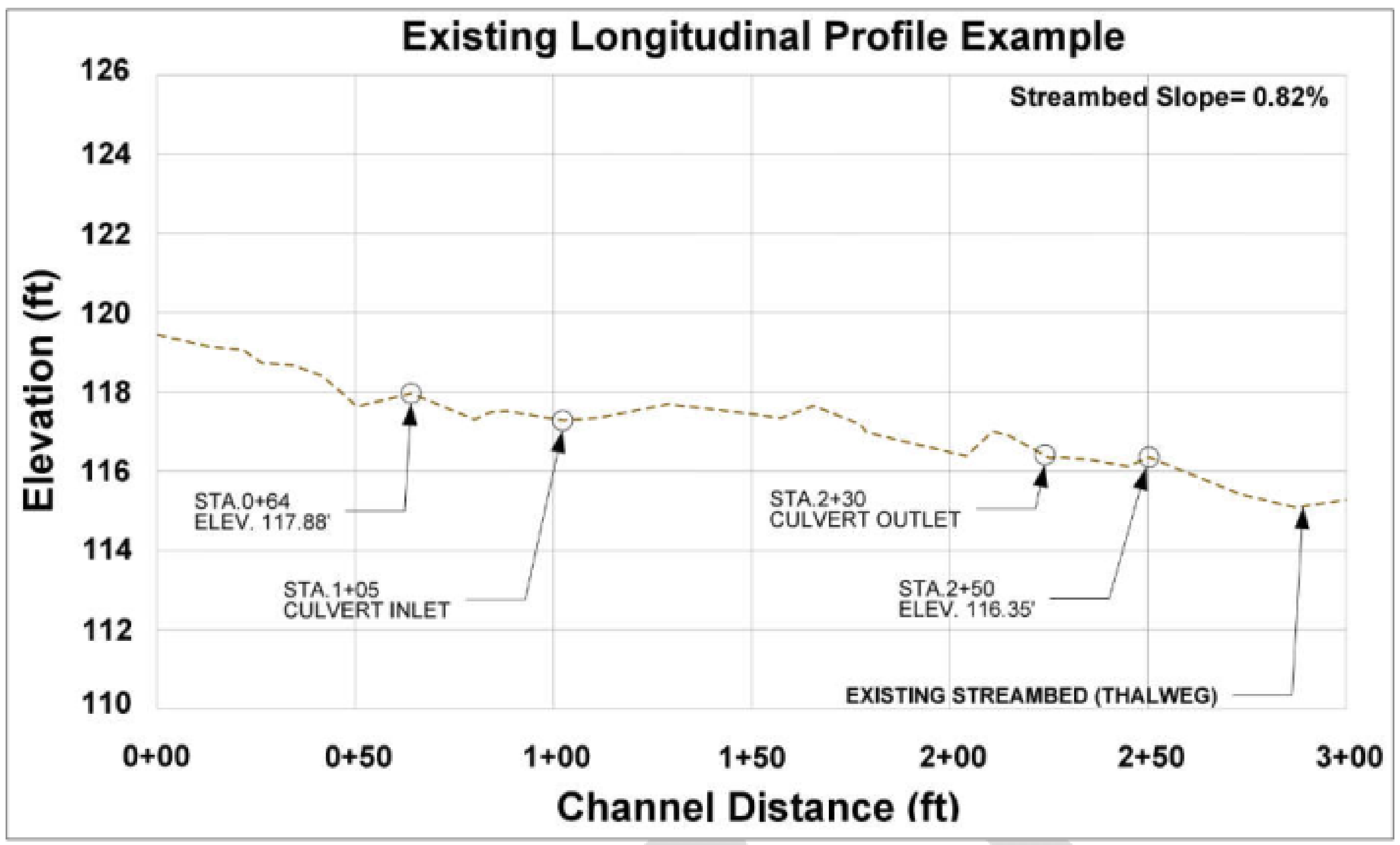
# Revised Culvert Conditions (2021)

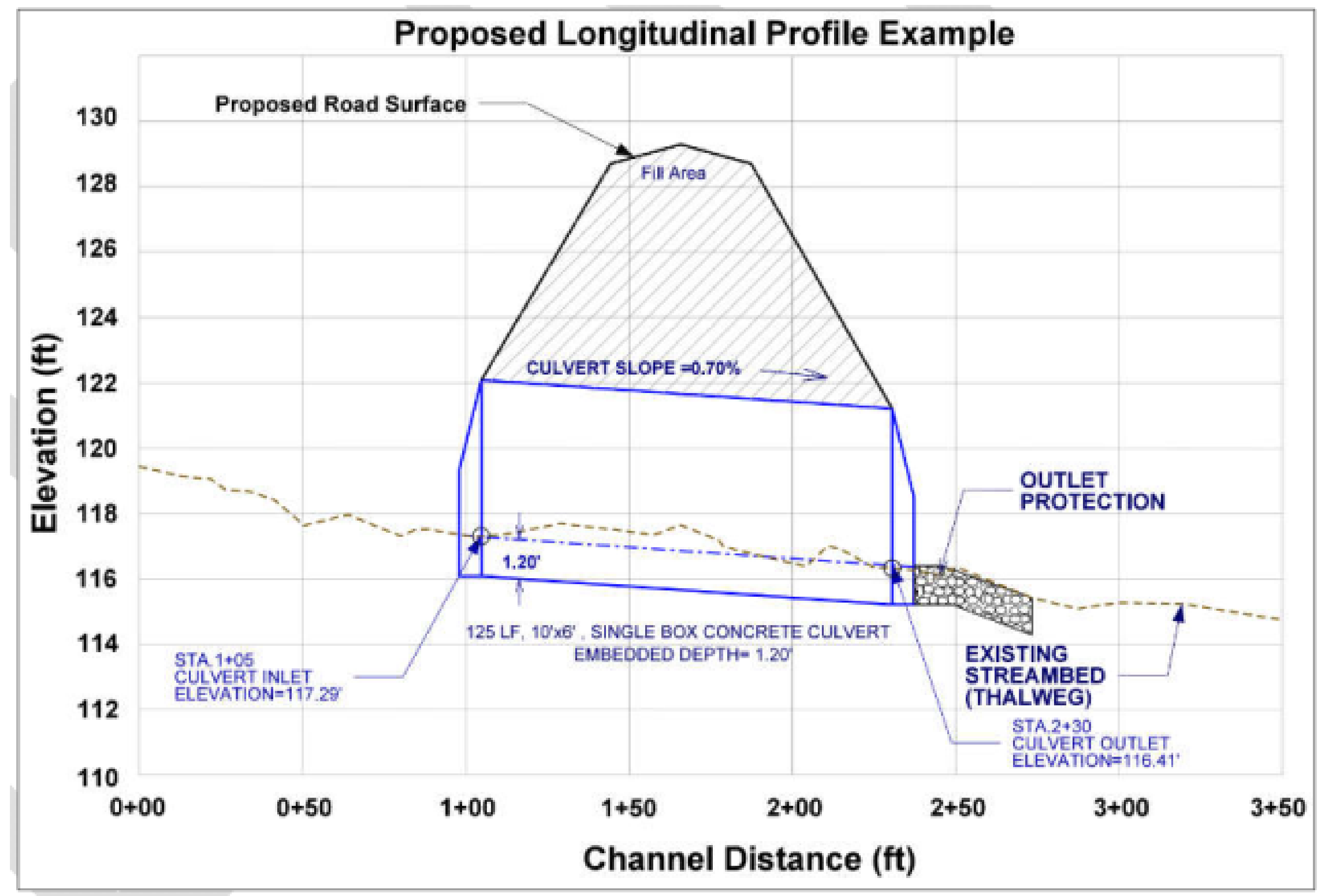



## New & Replacement Culverts

B. Diagrams
   1. Plan View
   2. Longitudinal Profile - Existing
   3. Longitudinal Profile – Proposed
   4. Representative Cross-Section
   5. Cross-Sections of Proposed Inlet/Outlet

# Revised Culvert Conditions (2021)



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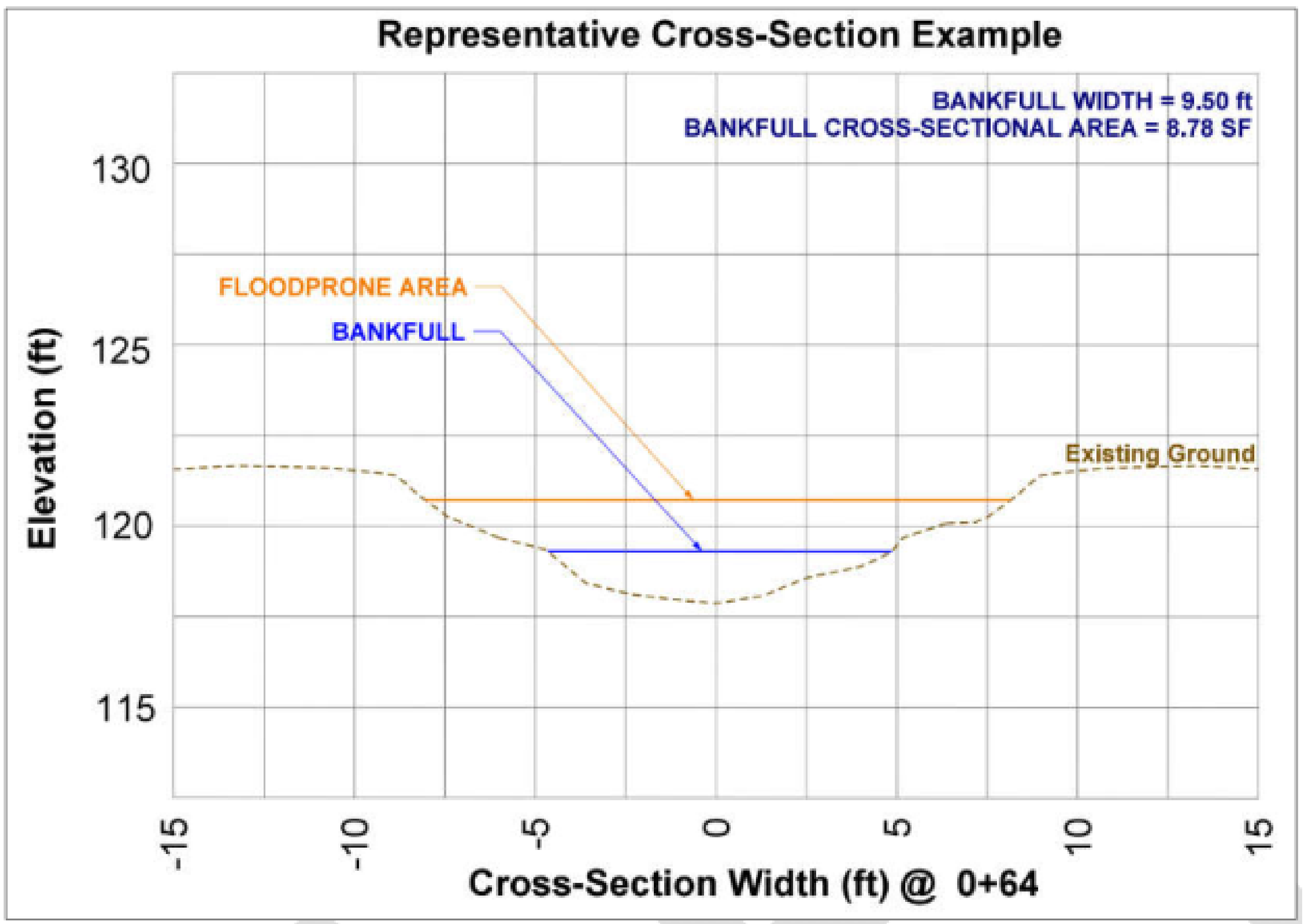


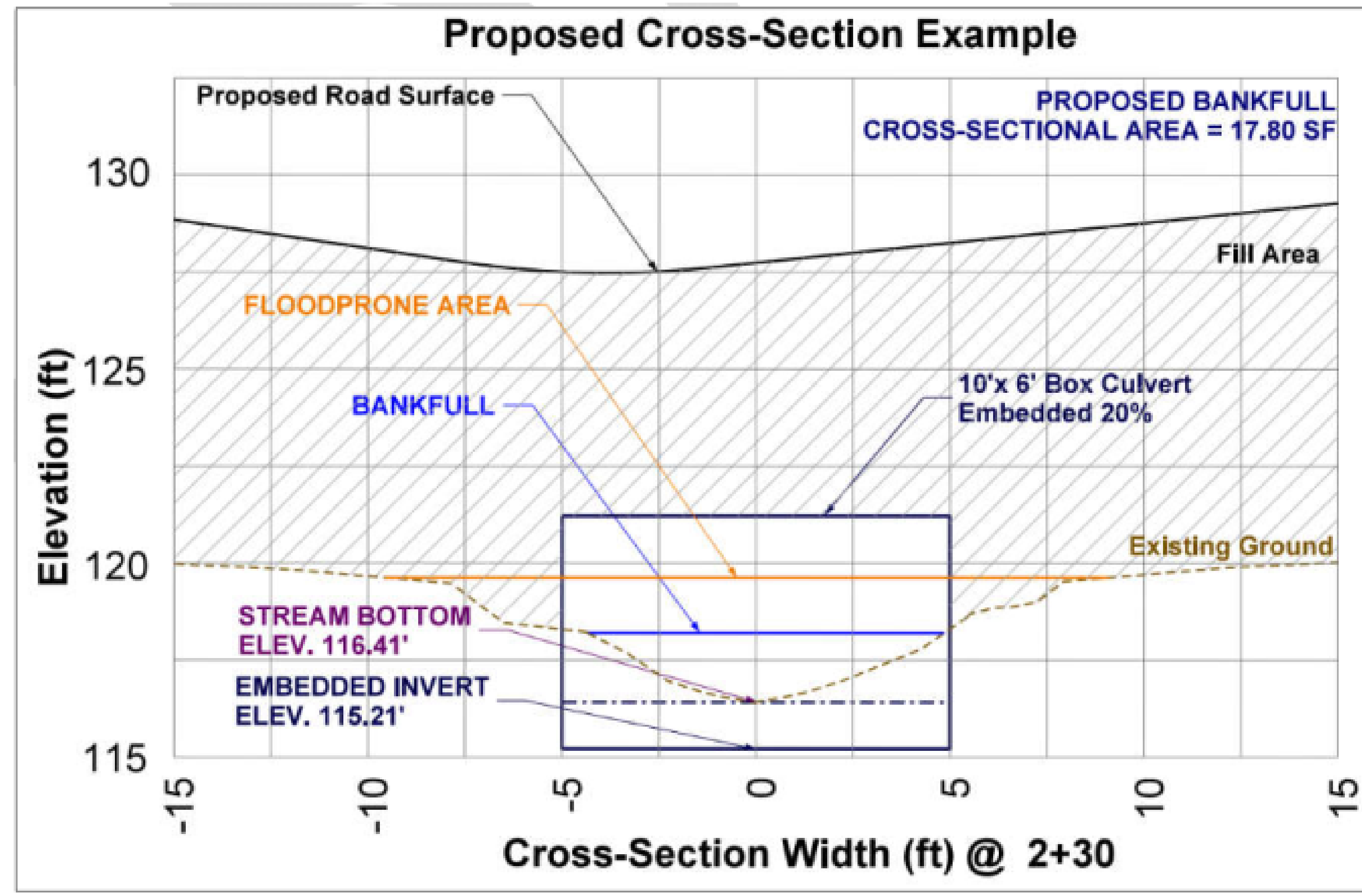

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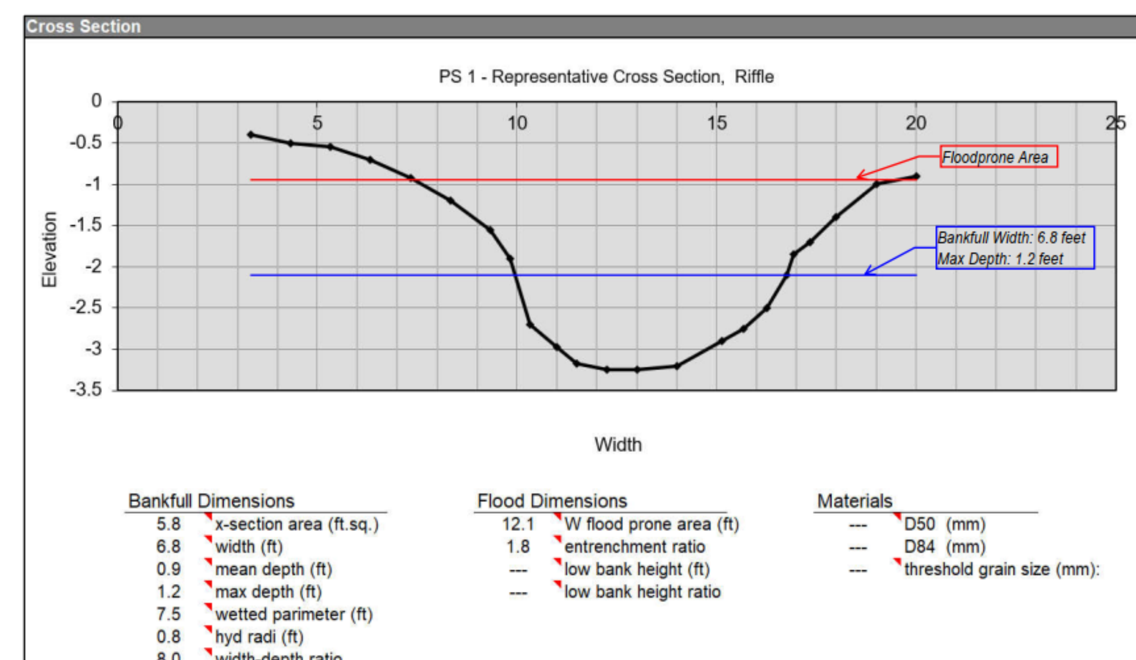
2. Proposed culvert extensions shall be assessed to determine whether baffles or other measures may be used to improve conditions for aquatic life passage. Documentation shall be provided on whether measures to improve aquatic connectivity are practicable. When practicable, these measures shall be implemented.

# Implementation is the key

- Guidance Now…and Later
  - Reactive → Proactive
  - Data collection
  - Coordination
  - Internal guidance
  - Permit submittals → Tell the Story!
- USACE Working Group
  - Programmatic and Project-Oriented



# USACE Culvert Conditions - Implementing

- Field Data Collection
- Coordination with Design
- Ongoing Projects
- Tips for Permit Applications

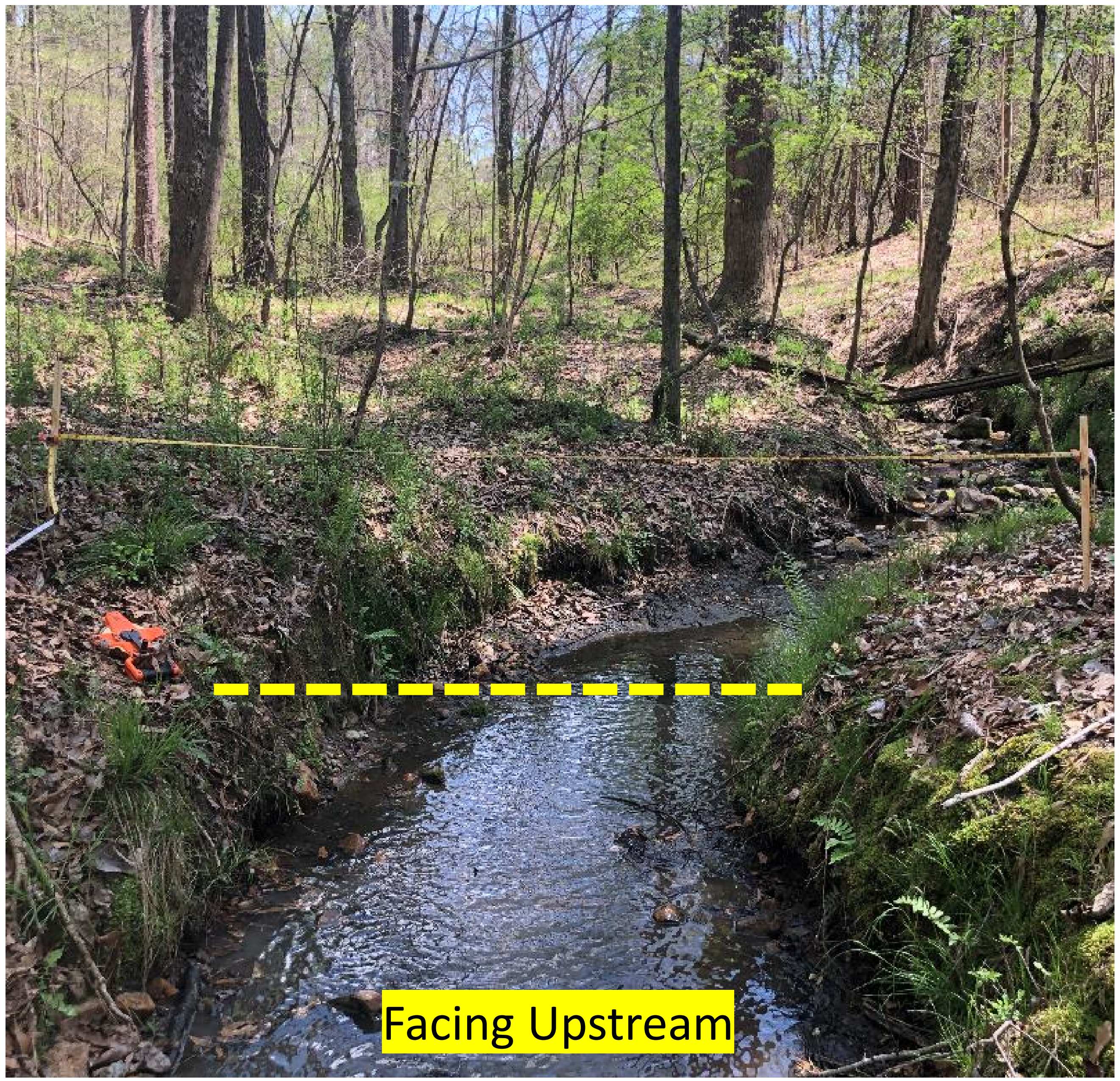
## USACE Culvert Conditions – Field Data Collection

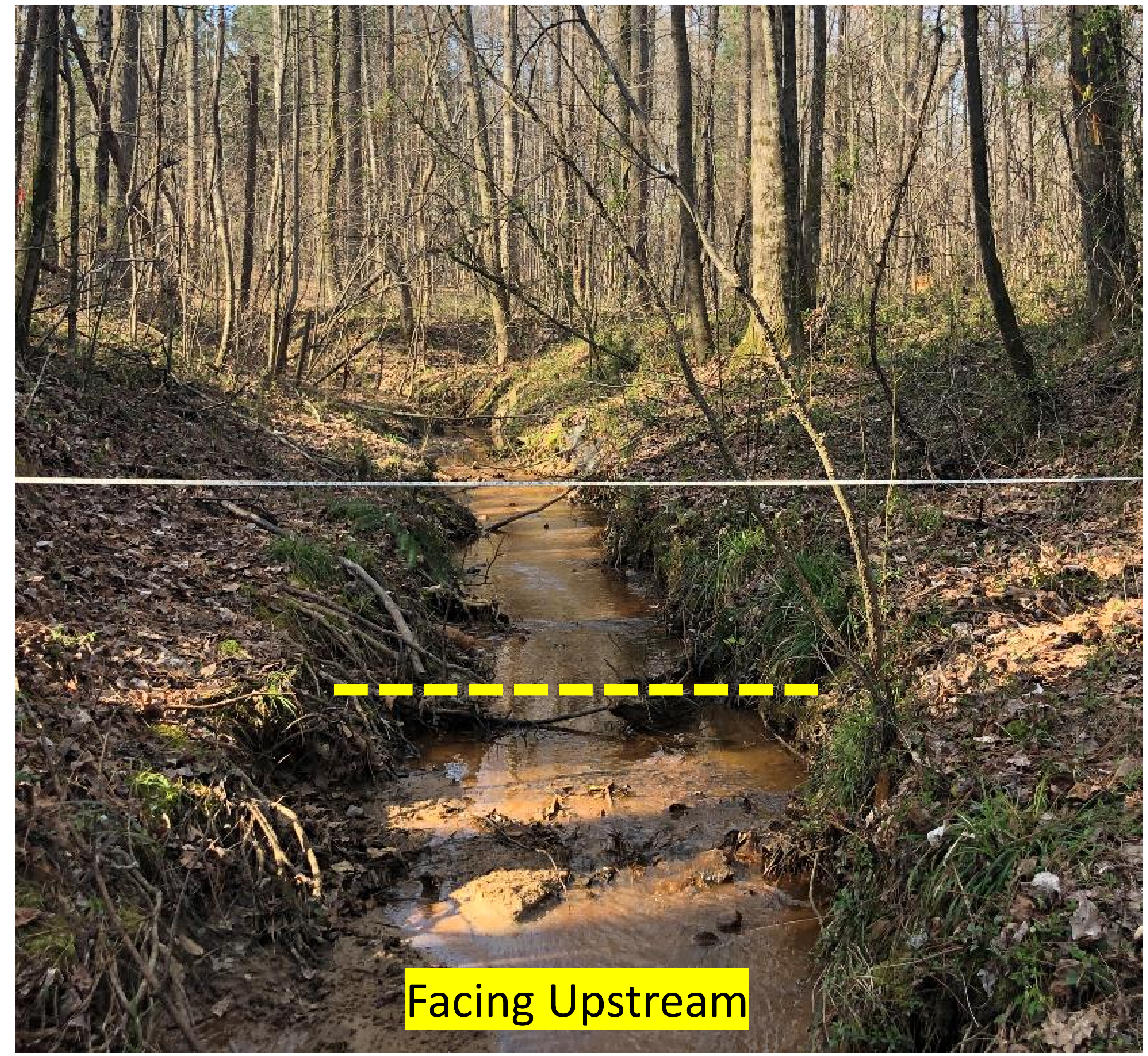
- New Projects → Resource ID, Perennial Streams
  - 1-2 Representative Channel Locations per Stream
    - Bankfull width/max depth measurements
    - GPS point
    - Photos – representative
  - Existing Culverts (per latest JCP/report template)
    - Photos of inlet/outlet
    - Aquatic passage documentation (e.g., perching, over or undersized culvert, flow condition, etc.)
  - Any other relevant notes/photos that provide context for the watershed (e.g., beaver activity, impoundments, etc.)


# USACE Culvert Conditions – Field Data Collection

- Identifying Representative Channel Locations
  - USACE Conditions:
    - “shall be measured, if possible, at a stable riffle or ripple [sand-bed dominated streams] located within and/or directly adjacent to the project area”
    - “shall be measured away from the influence of the existing culvert (usually 100’ upstream and/or 100’ downstream) → <u>use professional judgement, survey access as guides</u>
  - Find what’s **stable, typical, and most natural** for the stream
  - Avoid → pools, bends, overly wide/constricted sections, abnormal/impaired sections
  - Survey additional locations if needed (e.g., variation in stream, length of stream within survey) or if time allows

# USACE Culvert Conditions – Field Data Collection



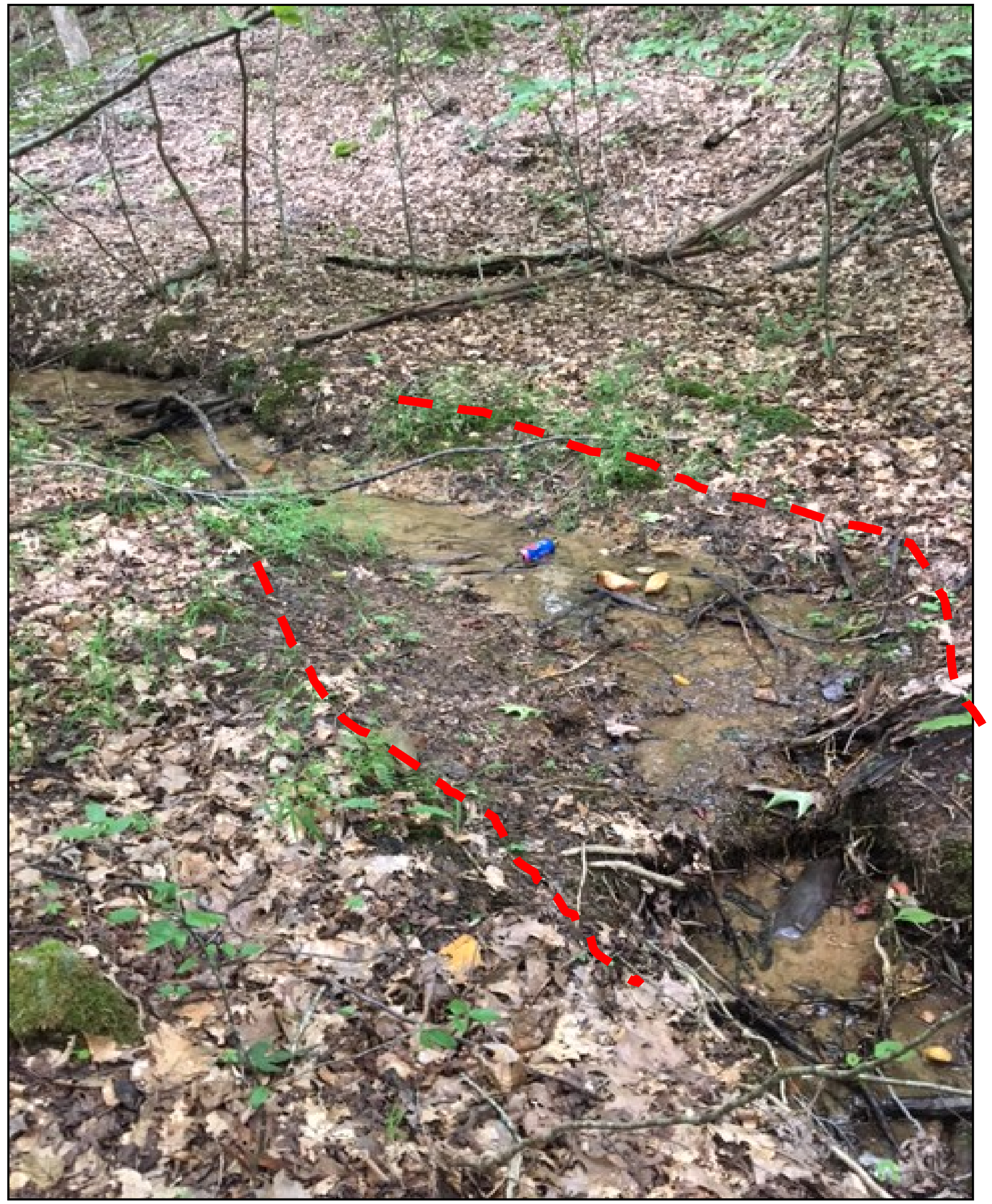
# Bankfull - Definition

BUILDING STRONG

- "The bankfull stage corresponds to **the discharge at which channel maintenance is the most effective**, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work results in the average morphologic characteristics of channels." (Dunne and Leopold, 1978)
- Bankfull usually has a recurrence interval corresponding to the **1.5-year storm**.
- **Common indicators** – Shelving, break in slope, wracklines/sediment deposition. Can be difficult to identify on impaired systems.
- **Regional Curves** – Reference stream dimensions used to develop dimensionless linear curves based upon watershed size.

# USACE-Provided:

# Bankfull Photos



## USACE-Provided:

## Tough Bankfull Calls

# USACE Culvert Conditions – Field Data Collection


Add'l Bankfull Guidance*

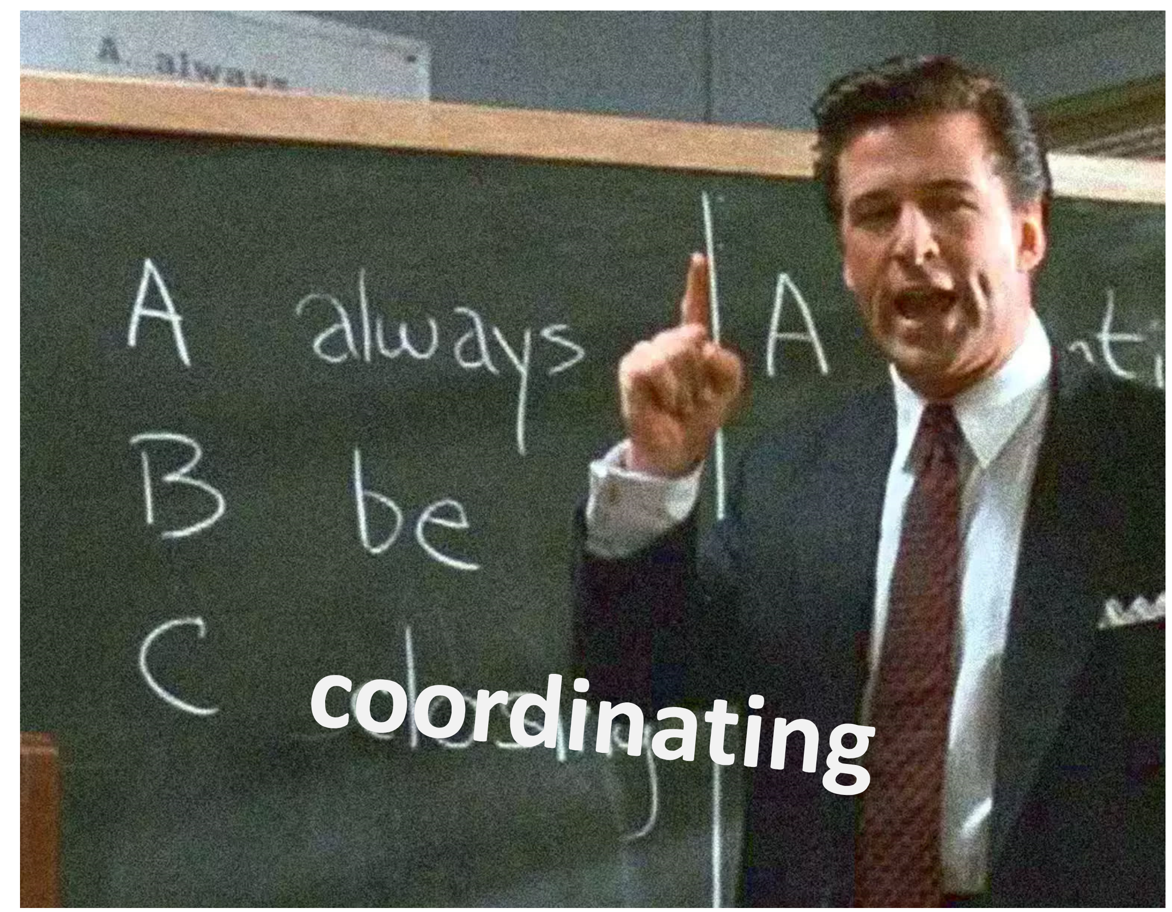
- Bankfull flow – elevation point of incipient flooding or "channel forming flow"
- Field indicators (in order of most to least reliable)
  - Change in Bank Slope
  - Depositional Features
  - Changes in Particle Size
  - Vegetation Changes
  - Scour Features

- Tips
  - Bankfull flows will be level across channel, so make sure your tape is level when measuring widths.
  - Think logically about a 1.5-year recurrence interval. Does it make sense that the points you are measuring as bankfull will see flow with that frequency?
  - On entrenched streams, bankfull elevation is often below the elevation of the "top of stream bank" due to many years of man-made impacts.
  - Note that tree roots and other vegetation can exist below the bankfull elevation, esp in dry years.

*Source: Penn State, Guidance in Determining Bankfull Stream Width in Pennsylvania

## USACE Culvert Conditions – Coordination with Design

- ESA Transmittal to Design
  - Along with resource delineations, send Design any perennial stream bankfull widths and corresponding GPS coordinates
- Avoidance and Minimization Measures Meeting (A3M)
  - Discuss bankfull widths in relation to any proposed culverts; go over culvert requirements with Design
  - Discuss existing culvert conditions (with regard to aquatic passage); advocate for replacements if warranted



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# USACE Culvert Conditions – Ongoing Projects

- Evaluate your existing data and whether it is sufficient to create the necessary culvert diagrams with confidence (Note: unlikely on current projects…)
  - Was a 404 Permit DTM survey conducted for this project?
  - If not, can you produce cross-sections with accurate, field-verified bankfull elevations? Do these match up with the current culvert design?
- Additional field visit may be needed to collect necessary data for diagrams → reach out to your project ecologist/Christina Schmidt to evaluate the best strategy for your project
  - Also communicate as early as possible with PM/Design → design modifications may be needed; there could be schedule implications

# USACE Culvert Conditions – Tips for Permit Application

- Provide Narrative and Photos →

## Tell the Story!

- Supplemental PCN Question #7 or potentially a separate attachment in the future
- Describe existing and proposed conditions and how culvert conditions are being met
- Describe any unique circumstances
- Provide explanations/justification in any instances where conditions can't be met
- Provide justification for extension versus replacement
- Include references to culvert diagrams
- Photos can have a big impact

7. Does the project involve construction or replacement of a culvert? (SC 16) Yes X No ____

**US Army Corps of Engineers, Savannah District**
**Pre-Construction Notification (PCN) Form**
**Additional PCN Information for Questions 1 through 18**

**State Route 85 over Lane Street, Meriwether County**

**1. Is the project funded by local, state, or federal government?**

Yes. The proposed project has been federally funded since its inception and the Federal Highway Administration (FHWA) is acting as the lead federal agency.

**5. Is the project located in a designated floodplain or floodway?**

No. The proposed project is not located within a designated floodplain or floodway. See Figure 4 in Attachment 3.

**6. Is a Georgia Stream Buffer Variance required for this project?**

Yes. A Georgia Stream Buffer Variance is required for impacts to the stream buffer of Perennial Stream (PS) 1. For a more complete description, please reference Section V.D of the 2021 Ecology Addendum (Attachment 6).

**7. Does the project involve construction or replacement of a culvert?**

Yes. The proposed project includes a culvert replacement/realignment on PS 1 at Lane Street and a culvert extension on PS 2 at State Route (SR) 85. See Figures 3-4 in Attachment 3 for locations; required diagrams are included in Attachment 5. Below, supplementary information and photos are provided.

**PS 1 Culvert Replacement/Realignment at Lane Street**

PS 1 is a small perennial stream which flows north into the proposed project area from a significantly perched culvert beneath a railroad parking area off Callaway Street, to the south of the project. Within the project area, the stream is generally clear with some areas containing high iron sheen and flocculants. Significant amounts of domestic trash, construction rubble, and discarded tires were observed throughout PS 1. PS 1 receives roadway and surface runoff from surrounding urban areas. At the representative cross-section, taken upstream of the existing culvert on Lane Street, PS 1 had a bankfull width of 6.8 feet and a maximum bankfull depth of 1.2 feet. The existing stream slope above the existing culvert is approximately 3.63%, while the slope below the culvert is approximately 2.70%. Overall the stream is incised and cannot access its floodplain.

# USACE Culvert Conditions – Tips for Permit Application

| | |
|---|---|
|  |  |
| **Photo 1:** PS 1 at representative cross-section and upstream of existing culvert on Lane Street (facing downstream); taken 1/30/21. | **Photo 2:** PS 1 upstream of representative cross-section (facing upstream); taken 1/30/21. |
|  |  |
| **Photo 3:** Inlet of existing culvert on PS 1 at Lane Street (facing downstream); taken 1/30/21. | **Photo 4:** Perched outlet of existing culvert on PS 1 at Lane Street (facing upstream); taken 1/30/21. |

# USACE Culvert Conditions – Tips for Permit Application

- Diagrams → Focus on Clarity
  - Review the USACE/GDOT diagram requirements/guidance and work w/ Design to match as much as possible
  - Table of Contents page for diagrams
  - PDF markups to make key information stand out
  - USACE is scrutinizing:
    - Representative bankfull width vs culvert width
    - Embedded depths
    - Stream/culvert alignment including any cut/fill that may be needed to connect these

**Perennial Stream 1**

**Culvert Replacement/Realignment at Lane Street – Diagrams:**

# Takeaways

## Perennial Stream Culverts – Ecologist's Perspective

- Work proactively with your project designer and PM during from concept phase through the permit application phase
- Begin with the end in mind: culvert width >= bankfull
- Prepare for your field visit by reviewing available, relevant information
- Gather accurate data in the field (i.e., bankfull)
- While on-site, gather photos and take careful notes on substrate and existing connectivity
- 404 permit conditions under the Clean Water Act are in addition to other related requirements under the Endangered Species Act, Fish and Wildlife Coordination Act, etc.
- Utilize forthcoming guidance and data sheets
- Approach the collaborative effort openly


QUESTIONS?

# Break time – take five

## Important Reminder:

- Two (2) PDH/CEU's available for those attending the entire session
- Email Gail D'Avino (gdavino@dot.ga.gov) to request a certificate by Friday July 30 – include
  - ✓ Name as you would like it to appear
  - ✓ Name of your employer
- Consider preparing your email during this break

Georgia Department of Transportation

# Perennial Stream Culverts: Design & Delivery Strategies

July 28th, 2021


## Sam Woods, P.E.

### Assistant State Roadway Design Engineer


**Plan Development Process**

3/10/2021
Revision 3.3
Atlanta, GA 30308

# Outline

### Context & engineer's mindset

- Application / scope / Plan Development Process
- A complete 1~~8~~0º → 90º

### Engineer's responsibilities

- Begin with the end in mind
- Environmental coordination
  - o Bankfull – regional curve equations
- Culvert design
  - o Bankfull – hydraulic modeling
  - o Selection of bankfull width → culvert width
  - o Culvert design
- Documentation & plan production
  - o Perennial stream culvert diagrams (39-series plans)

Concept Phase

Preliminary Design Phase

Final Design Phase

# Outline

**Context & engineer's mindset**

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Final Design Phase

# Application / Scope

✓ **Culverts on perennial streams**

- Ecologist identified & agency concurrence
- New culverts and culvert replacements → 39 Series drawings
- Existing culvert extensions → Evaluate for AOP & document decisions

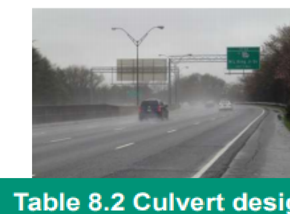
X **Culverts on:**

- Intermittent streams
- Ephemeral streams
- Wetlands

X **Bridges over perennial streams**

AOP = aquatic organism passage

# Application / Scope



## ✓ All culverts

- GDOT design criteria must be met (or design variance approved)
- Agency requirements (e.g. FEMA) must be met
- Engineering judgement should be used

## ✓ New or replacement culverts on perennial streams

- Embedment depth
- Longitudinal slope/grade considerations
- Bankfull width as driver for culvert width

Regional Conditions requirements

**Table 8.2 Culvert design criteria**

| Facility | Primary Criteria Roadway Base or Culvert Crown Elevation | | Secondary Criteria Shoulder Breakpoint or Culvert Crown Elevation | |
|---|---|---|---|---|
| | Required Clearance (ft) | Design Storm Frequency | Required Clearance (ft) | Check Storm Frequency |
| Interstates & State Routes | 1.0 | (1)50-yr | 1.0 ft below breakpoint | 100-yr |
| Hurricane Evacuation Routes | 1.0 | 50-yr | 1.0 ft below breakpoint | 100-yr |
| Non-state Routes:<br>ADT = 0-99<br>ADT = 100-399<br>ADT = 400-1499<br>ADT > 1499 | <br>1.0<br>1.0<br>1.0<br>1.0 | <br>5-yr<br>10-yr<br>25-yr<br>50-yr | <br>1.0 ft below breakpoint<br>1.0 ft below breakpoint<br>1.0 ft below breakpoint<br>1.0 ft below breakpoint | <br>10-yr<br>25-yr<br>50-yr<br>100-yr |
| Driveways | 1.0 | 25-yr | break point not overtopped | 50-yr |
| Temporary Detours | 1.0 | 10-yr | break point not overtopped | 25-yr |
| Permanent Culverts | 2.0 | 50-yr | 1 ft of crown clearance | 100-yr |
| Temporary Culverts:<br>Local roads, ADT < 400<br>All other roads | <br>1.0<br>1.0 | <br>2-yr<br>10-yr | <br>crown not overtopped<br>crown not overtopped | <br>5-yr<br>25-yr |

AOP = aquatic organism passage

# PDP Milestones

## Target milestones / primary goals

- Submit preliminary plans to GDOT Offices
- Environmental lockdown plans submittal

## Development / coordination milestones

- Environmental Resource identification
- Avoidance & minimization measures meeting (A3M)

## Check milestones

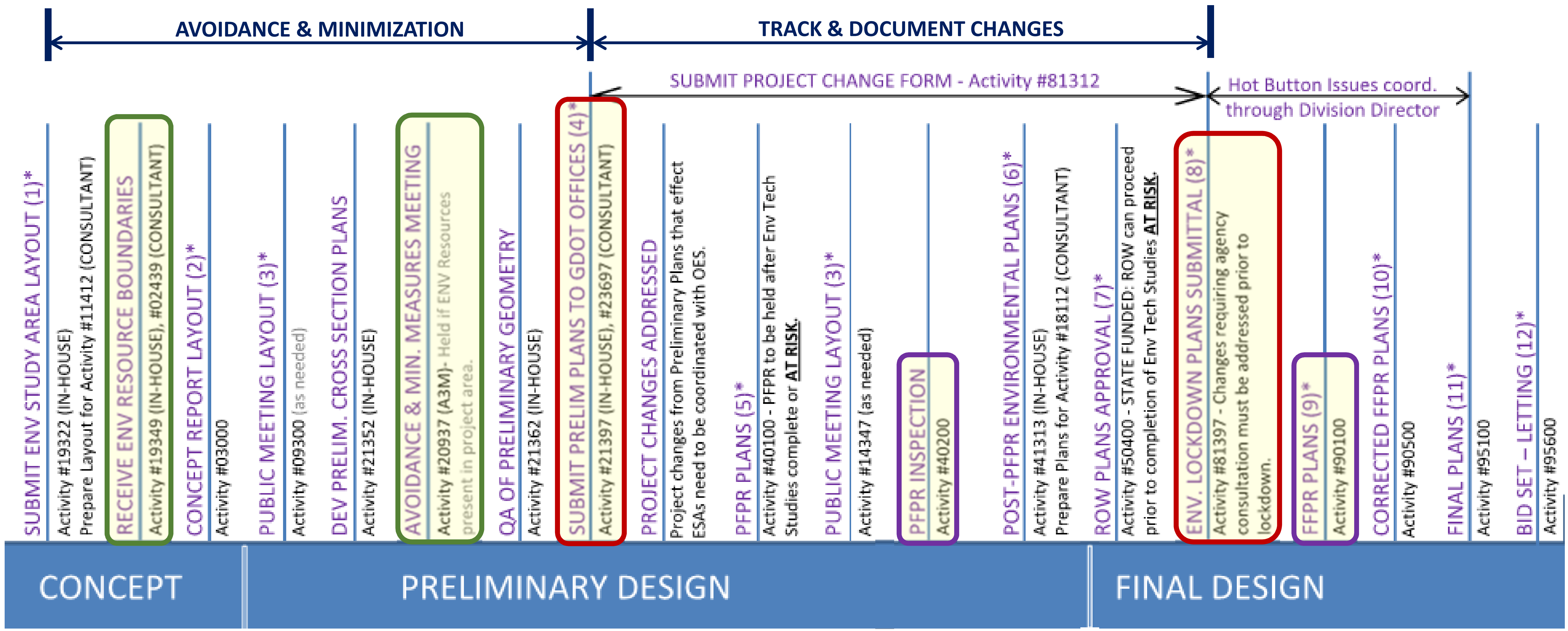
- Field plan reviews & constructability review

# PDP Milestones (Appendix O)

TARGET MILESTONE

DEVELOPMENT MILESTONE

CHECK MILESTONE



# Final Design Phase

## Guidance

### Plan Development Process (PDP)

**A3M Goals & Objectives**

The following goals have been developed in order to promote effective project delivery. A successful and well-documented A3M should result in:

- Environmental resources accurately delineated and noted in construction plans
- Impacts to Environmentally Sensitive Areas (ESA) are avoided and minimized to the greatest extent possible
- Project level discussions regarding impacting environmental resources occur early in the preliminary plans phase of the project, with the entire design and environmental teams represented and contributing in a collaborative manner.

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# Outline

## Context & engineer's mindset

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- **A complete $1\cancel{8}0^{\circ} \rightarrow 90^{\circ}$**

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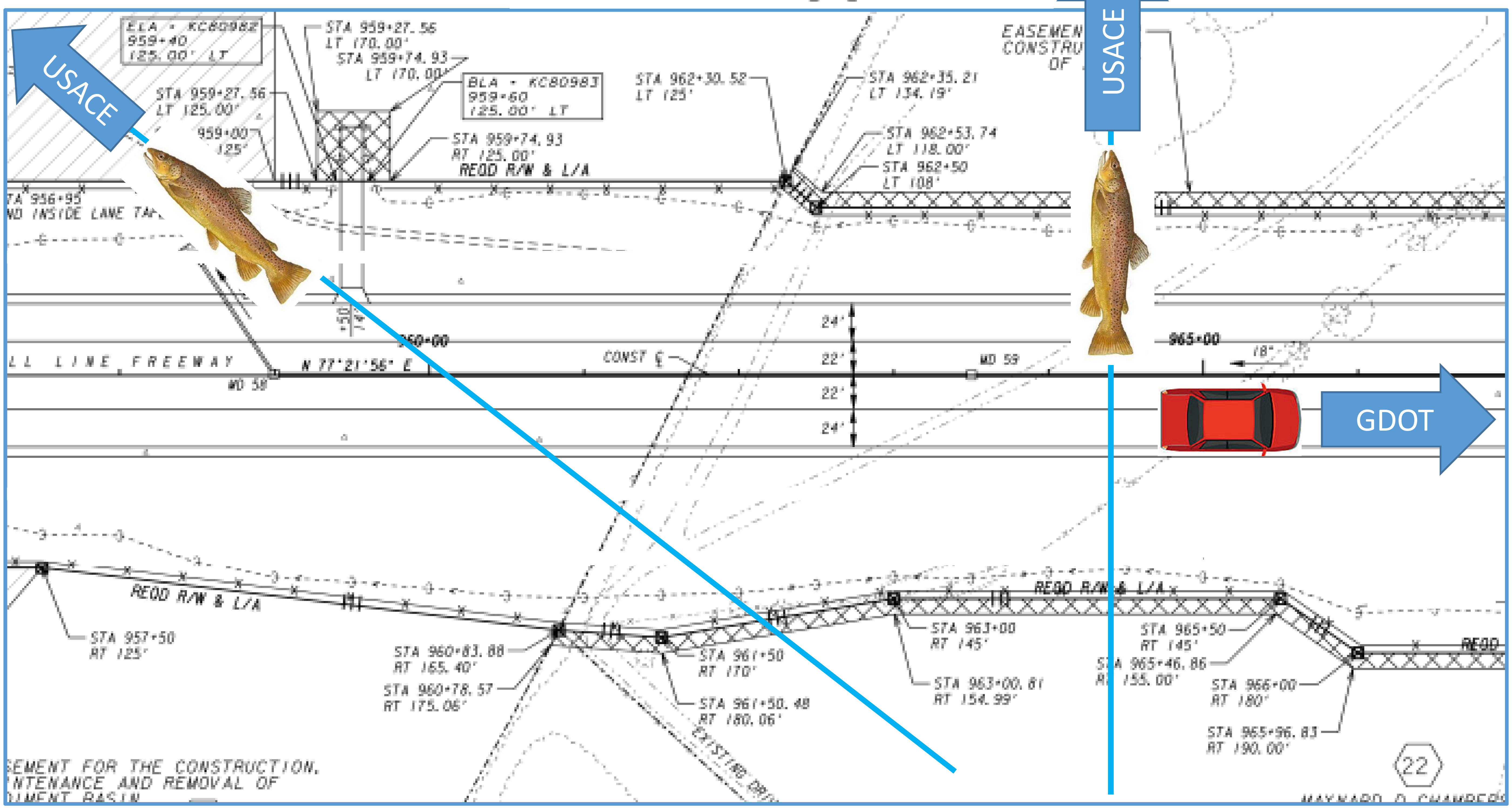
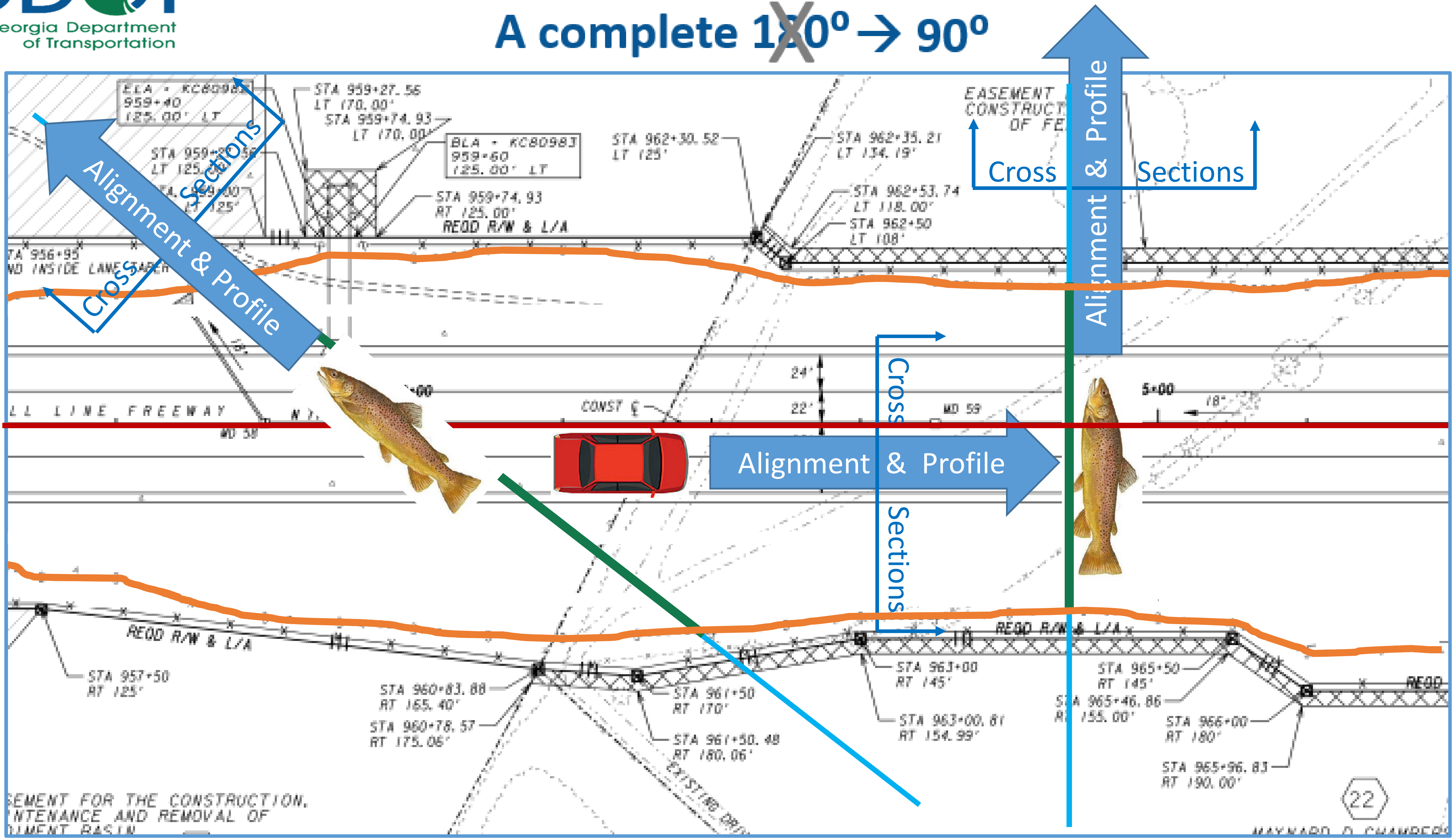
# A complete 1~~8~~0° → 90°

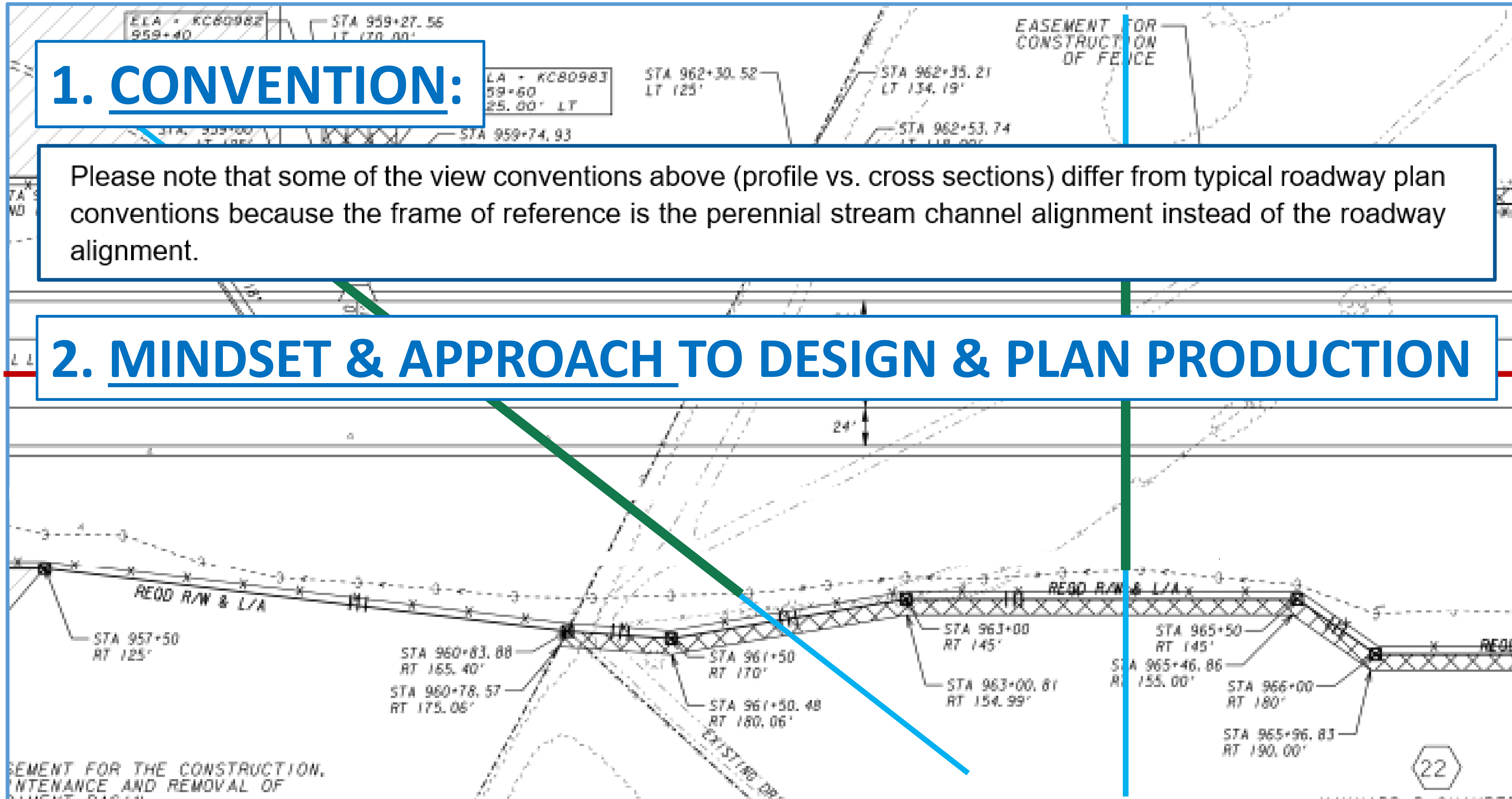


# A complete 1~~8~~0° → 90°




ROADWAY ALIGNMENT CONSTRUCTION LIMITS (CUT/FILL) STREAM ALIGNMENT PROPOSED CULVERT

# A complete 1~~8~~0° → 90°




## 1. CONVENTION:

Please note that some of the view conventions above (profile vs. cross sections) differ from typical roadway plan conventions because the frame of reference is the perennial stream channel alignment instead of the roadway alignment.

## 2. MINDSET & APPROACH TO DESIGN & PLAN PRODUCTION

# Outline

**Context & engineer's mindset**

- Application / scope / Plan Development Process
- A complete 180º → 90º

**Engineer's responsibilities**

- **Begin with the end in mind**
- Environmental coordination
  - o Bankfull – regional curve equations
- Culvert design
  - o Bankfull – hydraulic modeling
  - o Selection of bankfull width → culvert width
  - o Culvert design
- Documentation & plan production
  - o Perennial stream culvert diagrams (39-series plans)

Concept Phase

Preliminary Design Phase

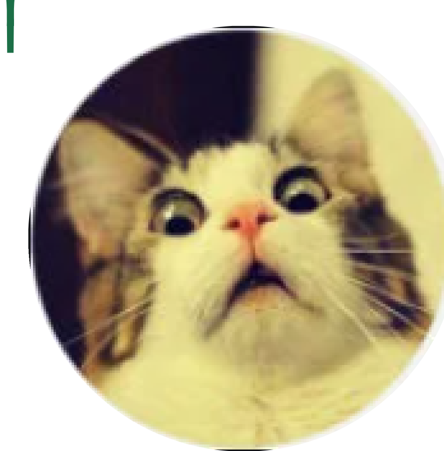
Final Design Phase

## Designer's Perspective

## Begin with the end in mind

- Objective = design the "correct" culvert with respect to:

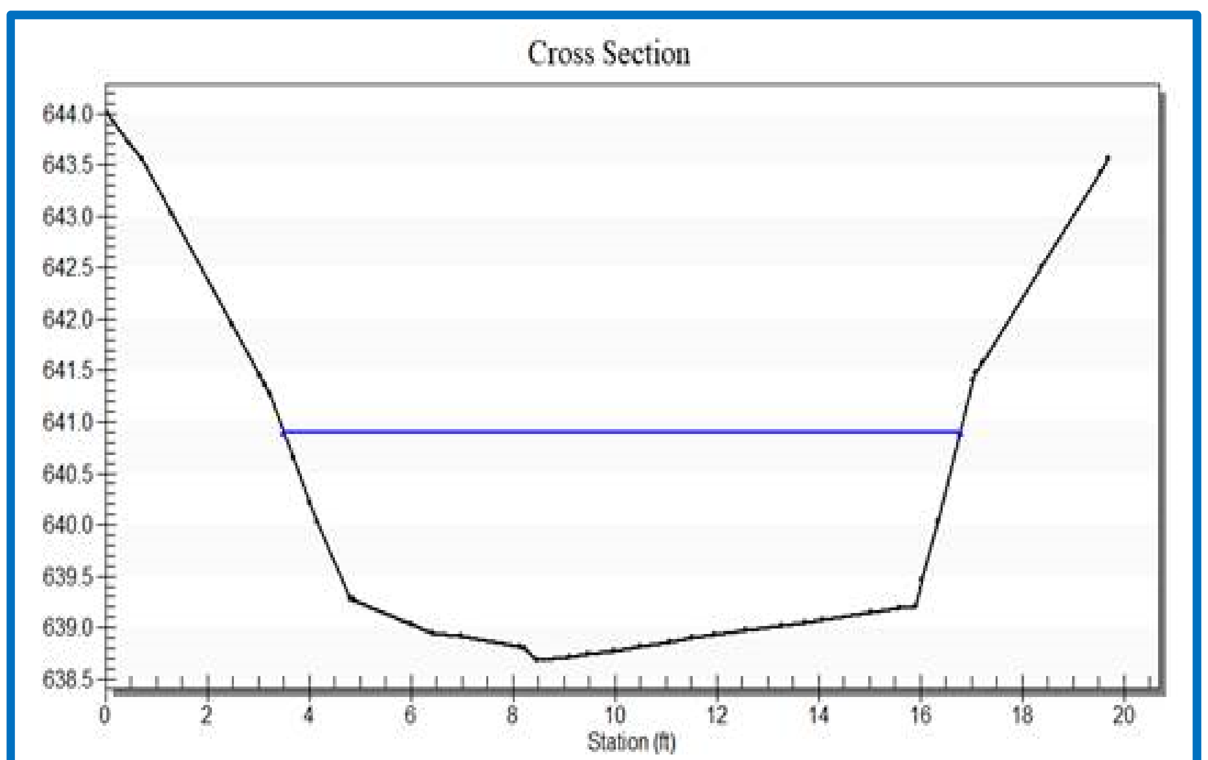
1. Culvert embedment at 20% of culvert height
2. Culvert slope ⇔ stream channel slope
3. Culvert width ⇔ bankfull width



# Begin with the end in mind

# Bankfull Methodologies

1. Regional curve equations
2. Ecologist field measurements
3. Hydraulic modeling




**Predictive Stream Variables**

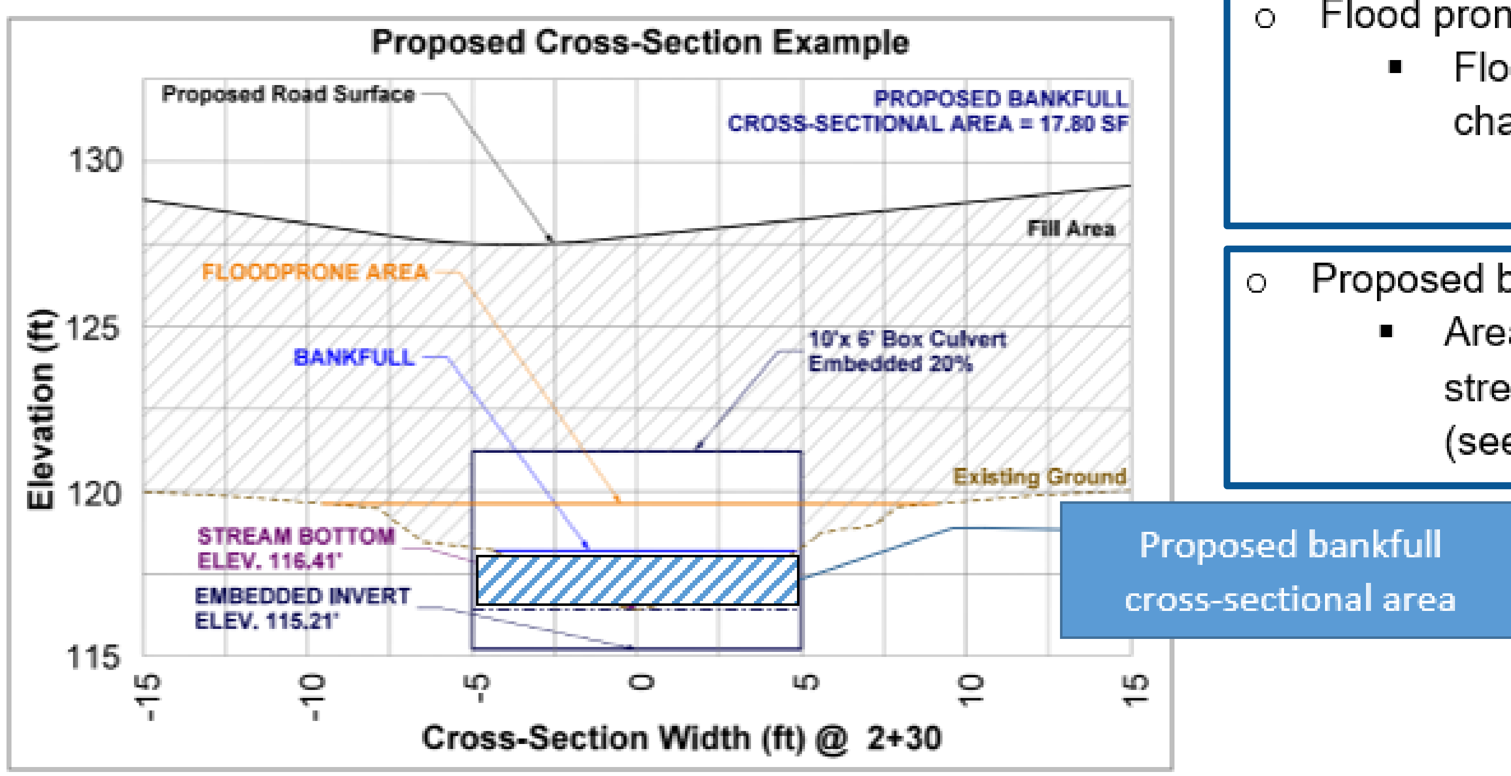
**Georgia Coastal Plain Regional Curve Calculations**

| | | | | |
|---|---|---|---|---|
| Watershed Size (sq. mi.) | Enter Here --> | 0.51 | | |
| ***Abkf*** | 5.93 | (I7)^0.72)) | 3.65 | sq. ft. |
| ***Wbkf*** | 8.59 | (I7)^0.34)) | 6.83 | ft. |
| ***Dbkf*** | 0.68 | (I7)^0.38)) | 0.53 | ft. |

# Begin with the end in mind

# Bankfull Methodologies

- Before designing culverts, read Perennial Stream Culvert Diagrams guidance & Regional Conditions
- Recognize which items <u>directly influence culvert design</u> (e.g. embedment, grade, bankfull width)
- Recognize which items are <u>required on diagrams</u> but do not influence culvert design (e.g. flood prone area, bankfull cross sectional area)




- Flood prone "area":
  - Flood prone "area" should be shown graphically by a horizontal line within the stream channel, at a depth twice the bankfull depth (see diagram below)
    - Flood prone elevation = stream bottom elevation + (2 * bankfull depth)

- Proposed bankfull cross-sectional area (square feet) value should be shown
  - Area bounded by the horizontal bankfull elevation line on the top, bounded by the existing stream bottom elevation on the bottom, and bounded by the proposed culvert on the sides (see diagram below)

# Outline

**Context & engineer's mindset**

- Application / scope / Plan Development Process
- A complete ~~180º~~ → 90º

**Engineer's responsibilities**

- Begin with the end in mind
- **Environmental coordination**
  - **Bankfull – regional curve equations**
- Culvert design
  - Bankfull – hydraulic modeling
  - Selection of bankfull width → culvert width
  - Culvert design
- Documentation & plan production
  - Perennial stream culvert diagrams (39-series plans)

Concept Phase

Preliminary Design Phase

Final Design Phase

# Environmental coordination

- Project location / Environmental Survey Boundary (ESB)
- Existing culvert information
- Existing stream data
  - USGS maps & StreamStats
  - Field visit
- Bankfull estimation
  - Regional curve equations

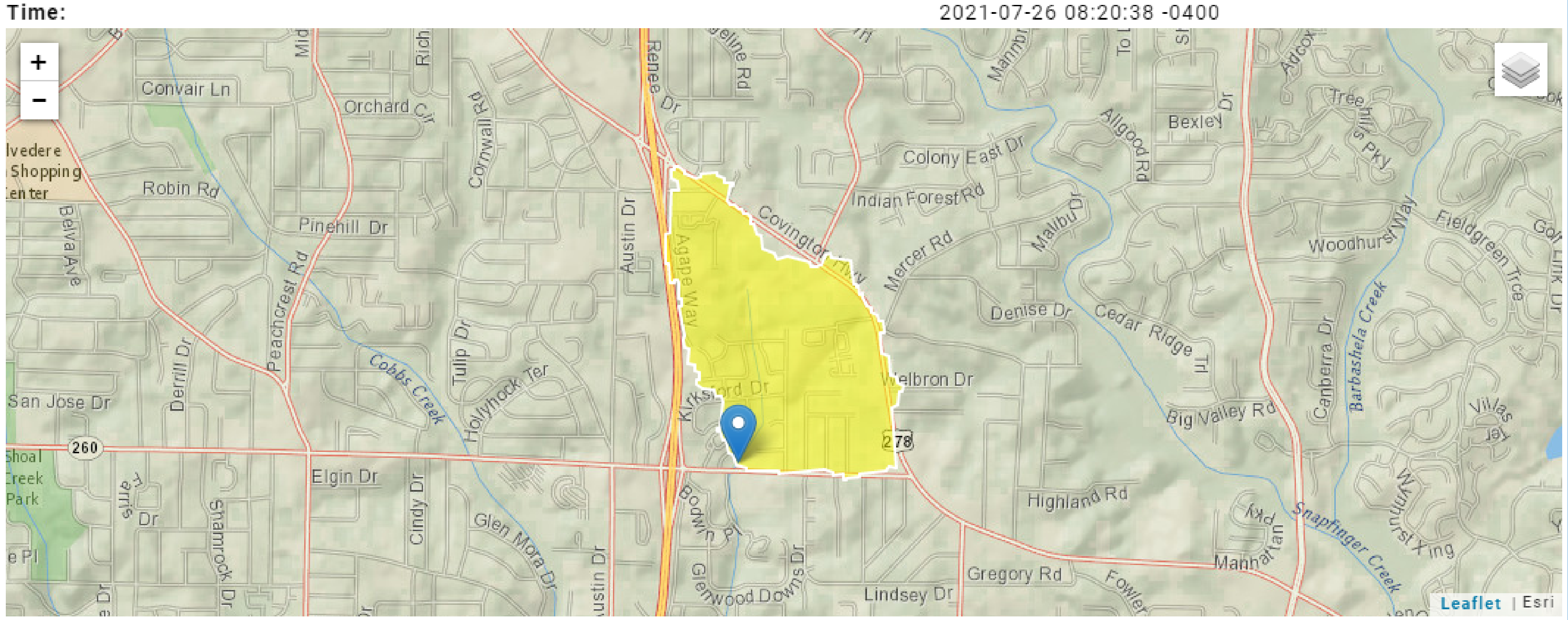
Georgia Department of Transportation

# Concept Phase

# Bankfull – Regional Curve Equations

## StreamStats Report

| | |
|---|---|
| **Region ID:** | GA |
| **Workspace ID:** | GA20210726122021568000 |
| **Clicked Point (Latitude, Longitude):** | 33.73744, -84.22690 |
| **Time:** | 2021-07-26 08:20:38 -0400 |




Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| DRNAREA | Area that drains to a point on a stream | 0.51 | square miles |

## Predictive Stream Variables

**Georgia Coastal Plain Regional Curve Calculations**

Watershed Size (sq. mi.) Enter Here --> 0.51

| | | | | |
|---|---|---|---|---|
| ***Abkf*** | 5.93 | (I7)^0.72)) | 3.65 | sq. ft. |
| ***Wbkf*** | 8.59 | (I7)^0.34)) | 6.83 | ft. |
| ***Dbkf*** | 0.68 | (I7)^0.38)) | 0.53 | ft. |

| | |
|---|---|
| Drainage Area (AC) | 326.4 |
| Drainage Area (SQ MILES) | 0.51 |
| | |
| | Bankfull Width (ft) |
| GA Costal Plain | 6.83 |
| NC Urban Piedmont (Doll) | 19.53 |
| NC Rural Piedmont (Doll) | 11.39 |
| NC Mountain A | 14.85 |
| NC Mountain B | 10.18 |
| NC Coastal | 8.61 |
| SC Blue Ridge | 13.25 |
| SC Piedmont | 9.96 |
| SC SE Plains | 6.51 |
| TN Blue Ridge | 12.03 |
| TN Ridge & Valley | 12.63 |
| AL Rural Piedmont | 14.26 |
| FL North Coastal Plain: C-type stream | 8.27 |
| FL North Coastal Plain: E-type stream | 4.79 |
| FL North West Coastal Plain: C-type stream | 6.44 |
| FL North West Coastal Plain: E-type stream | 9.28 |

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# Outline

**Context & engineer's mindset**

- Application / scope / Plan Development Process
- A complete ~~180º~~ → 90º

**Engineer's responsibilities**

- Begin with the end in mind
- Environmental coordination
  - Bankfull – regional curve equations
- **Culvert design**
  - **Bankfull – hydraulic modeling**
  - **Selection of bankfull width → culvert width**
  - **Culvert design**
- Documentation & plan production
  - Perennial stream culvert diagrams (39-series plans)

Concept Phase

Preliminary Design Phase

Final Design Phase

## Culvert Design

- Environmental resource ID complete
  - Ecologist bankfull field measurement
- Survey database complete
  - Additional 404 survey no longer required
- Decisions on existing culverts – extend or replace?
  - Document data collection and decision making (ecologist)
- Layout & design of new / replacement culverts
  - Hydraulic modeling of bankfull

## Culvert Design

- Extending/retaining existing culverts:
  - Existing single-barrel
    - Improving AOP through culvert cross section modification is not usually practical, however
    - Improving AOP may be possible through improved tie-ins of culvert extensions to the existing stream
    - No hydraulic modeling

AOP = aquatic organism passage

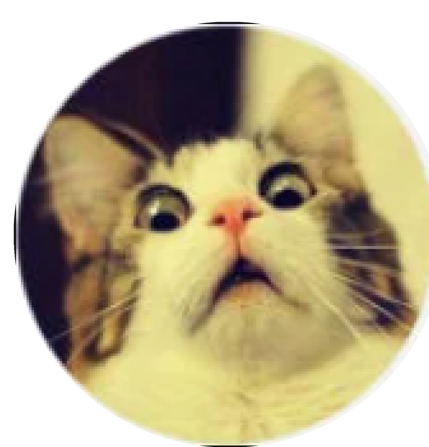
## Culvert Design

- Extending/retaining existing culverts:
  - Existing multi-barrel
    - Evaluate hydraulic capacity of existing culvert
    - If additional capacity is available consider baffling the barrel(s) not carrying the main channel to bankfull height
      - Hydraulic modeling done only in this case for existing culverts

## Culvert Design

- Objective = design the "correct" culvert with respect to:

    1. Culvert embedment at 20% of culvert height
    2. Culvert slope ⇔ stream channel slope
    3. Culvert width ⇔ bankfull width



Hydraulic Modeling

# Preliminary Design Phase

## Hydraulic modeling of bankfull - What's the same?

- Delineate area & select appropriate hydrologic method
- Analysis tools (Manning's equation calculators):
  - FlowMaster, CivilStorm, Hydraulic Toolbox

**Table 4.2 – Limitations for Hydrologic Methods**

| Method | Watershed Area Limitation | Notes |
|---|---|---|
| Rational | 0 - 200 acres | Recommended for basins < 64 acres |
| NRCS TR-55 Method | Usually < 2,000 acres and has hydrologic homogeneity | None |
| USGS Urban Regression Equations | See most current USGS publication | 1.0 $mi^2$ = 640 acres |
| USGS Rural Regression Equations | See most current USGS publication | 1.0 $mi^2$ = 640 acres |

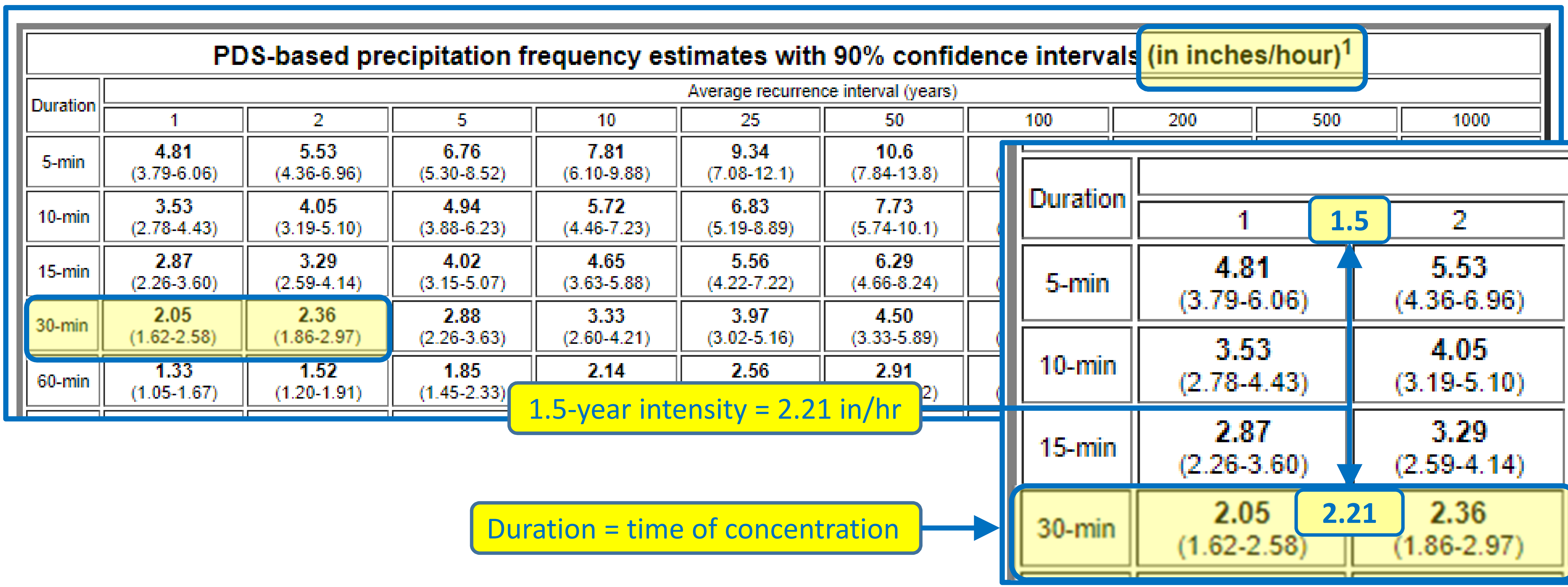
## Hydraulic modeling of bankfull - What's new?

- Focus: culvert → stream
  - Study area: culvert inlet → stream cross section
  - Manning's n-value: culvert → stream
- Approx. bankfull storm event in Georgia → **1.5-year storm**

| Hydrologic Method | Math | Data Used | | | Result |
|---|---|---|---|---|---|
| Rational | Linear interpolation | Intensity (in/hr) | 1-year storm | 2-year storm | 1.5-year Intensity --> 1.5-year Flow |
| NRCS TR-55 | Linear interpolation | Depth (in) | 1-year storm | 2-year storm | 1.5-year Depth --> 1.5-year Flow |
| USGS Regression | Linear extrapolation | Flow (qfs) | 2-year storm | 5-year storm | 1.5-year Flow |

# Preliminary Design Phase – Hydraulic Modeling

## Rational Method - intensity



| Duration | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|---|---|---|
| PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1] — Average recurrence interval (years) | | | | | | | | | | |
| 5-min | 4.81 (3.79-6.06) | 5.53 (4.36-6.96) | 6.76 (5.30-8.52) | 7.81 (6.10-9.88) | 9.34 (7.08-12.1) | 10.6 (7.84-13.8) | | | | |
| 10-min | 3.53 (2.78-4.43) | 4.05 (3.19-5.10) | 4.94 (3.88-6.23) | 5.72 (4.46-7.23) | 6.83 (5.19-8.89) | 7.73 (5.74-10.1) | | | | |
| 15-min | 2.87 (2.26-3.60) | 3.29 (2.59-4.14) | 4.02 (3.15-5.07) | 4.65 (3.63-5.88) | 5.56 (4.22-7.22) | 6.29 (4.66-8.24) | | | | |
| 30-min | 2.05 (1.62-2.58) | 2.36 (1.86-2.97) | 2.88 (2.26-3.63) | 3.33 (2.60-4.21) | 3.97 (3.02-5.16) | 4.50 (3.33-5.89) | | | | |
| 60-min | 1.33 (1.05-1.67) | 1.52 (1.20-1.91) | 1.85 (1.45-2.33) | 2.14 | 2.56 | 2.91 | | | | |

# Preliminary Design Phase – Hydraulic Modeling

## NRCS – TR55 Method - depth

**PDS-based precipitation frequency estimates with 90% confidence intervals**

| Duration | Average recurrence interval (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 |
| 5-min | **0.397** (0.309-0.498) | **0.458** (0.356-0.574) | **0.560** (0.435-0.703) | **0.647** (0.500-0.815) | **0.772** (0.582-0.993) | **0.871** (0.645-1.13) | **0.973** (0.701-1.28) |
| 10-min | **0.581** (0.453-0.729) | **0.670** (0.522-0.841) | **0.820** (0.636-1.03) | **0.948** (0.732-1.19) | **1.13** (0.853-1.45) | **1.27** (0.944-1.65) | **1.43** (1.03-1.87) |
| 15-min | **0.709** (0.552-0.889) | **0.817** (0.636-1.02) | **1.00** (0.776-1.26) | **1.16** (0.893-1.46) | **1.38** (1.04-1.77) | **1.56** (1.15-2.01) | **1.74** (1.25-2.28) |
| 30-min | **1.02** (0.797-1.28) | **1.18** (0.917-1.48) | **1.44** (1.12-1.81) | **1.66** (1.29-2.10) | **1.98** (1.50-2.55) | **2.24** (1.65-2.89) | **2.50** (1.80-3.28) |
| 60-min | **1.32** (1.03-1.66) | **1.52** (1.18-1.90) | **1.85** (1.43-2.32) | **2.14** (1.65-2.69) | **2.56** (1.93-3.30) | **2.90** (2.15-3.76) | **3.25** (2.35-4.28) |
| 2-hr | **1.62** (1.28-2.01) | **1.85** (1.46-2.30) | **2.26** (1.77-2.80) | **2.61** (2.04-3.25) | **3.13** (2.40-4.00) | **3.56** (2.68-4.57) | **4.01** (2.93-5.22) |
| 3-hr | **1.81** (1.44-2.23) | **2.06** (1.63-2.54) | **2.49** (1.97-3.[illegible] | [illegible] | [illegible] | [illegible] (3.00-5.05) | **4.46** (3.30-5.78) |
| 6-hr | **2.22** (1.79-2.70) | **2.49** (2.00-3.03) | **2.98** (2.39-3.63) | **3.42** (2.73-4.18) | **4.10** (3.23-5.17) | **4.67** (3.60-5.92) | **5.29** (3.97-6.79) |
| 12-hr | **2.75** (2.24-3.30) | **3.05** (2.49-3.67) | **3.61** (2.93-4.34) | **4.11** (3.33-4.97) | **4.88** (3.89-6.08) | **5.53** [illegible] | [illegible] |
| 24-hr | **3.29** (2.72-3.91) | **3.70** (3.05-4.39) | **4.41** (3.63-5.24) | **5.03** (4.13-6.00) | **5.95** (4.79-7.29) | [illegible] | [illegible] (5.77-9.37) |

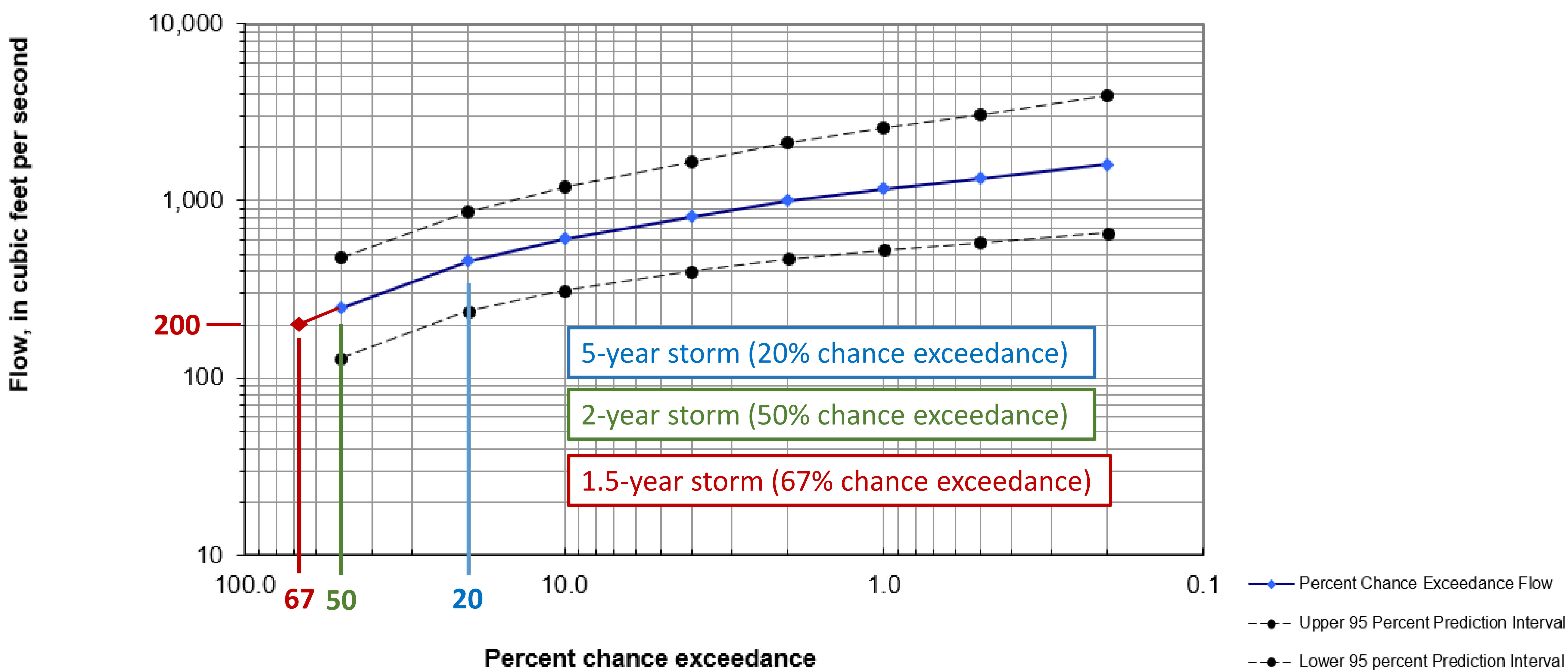
1.5-year depth = 3.50 in

Duration = 24-hr


| Duration | 1 | 1.5 | 2 |
|---|---|---|---|
| 5-min | **0.397** (0.309-0.498) | | **0.458** (0.356-0.574) |
| 10-min | **0.581** (0.453-0.729) | | **0.670** (0.522-0.841) |
| 15-min | **0.709** (0.552-0.889) | | **0.817** (0.636-1.02) |
| 30-min | **1.02** (0.797-1.28) | | **1.18** (0.917-1.48) |
| 60-min | **1.32** (1.03-1.66) | | **1.52** (1.18-1.90) |
| 2-hr | **1.62** (1.28-2.01) | | **1.85** (1.46-2.30) |
| 3-hr | **1.81** (1.44-2.23) | | **2.06** (1.63-2.54) |
| 6-hr | **2.22** (1.79-2.70) | | **2.49** (2.00-3.03) |
| 12-hr | **2.75** (2.24-3.30) | | **3.05** (2.49-3.67) |
| 24-hr | **3.29** (2.72-3.91) | 3.50 | **3.70** (3.05-4.39) |

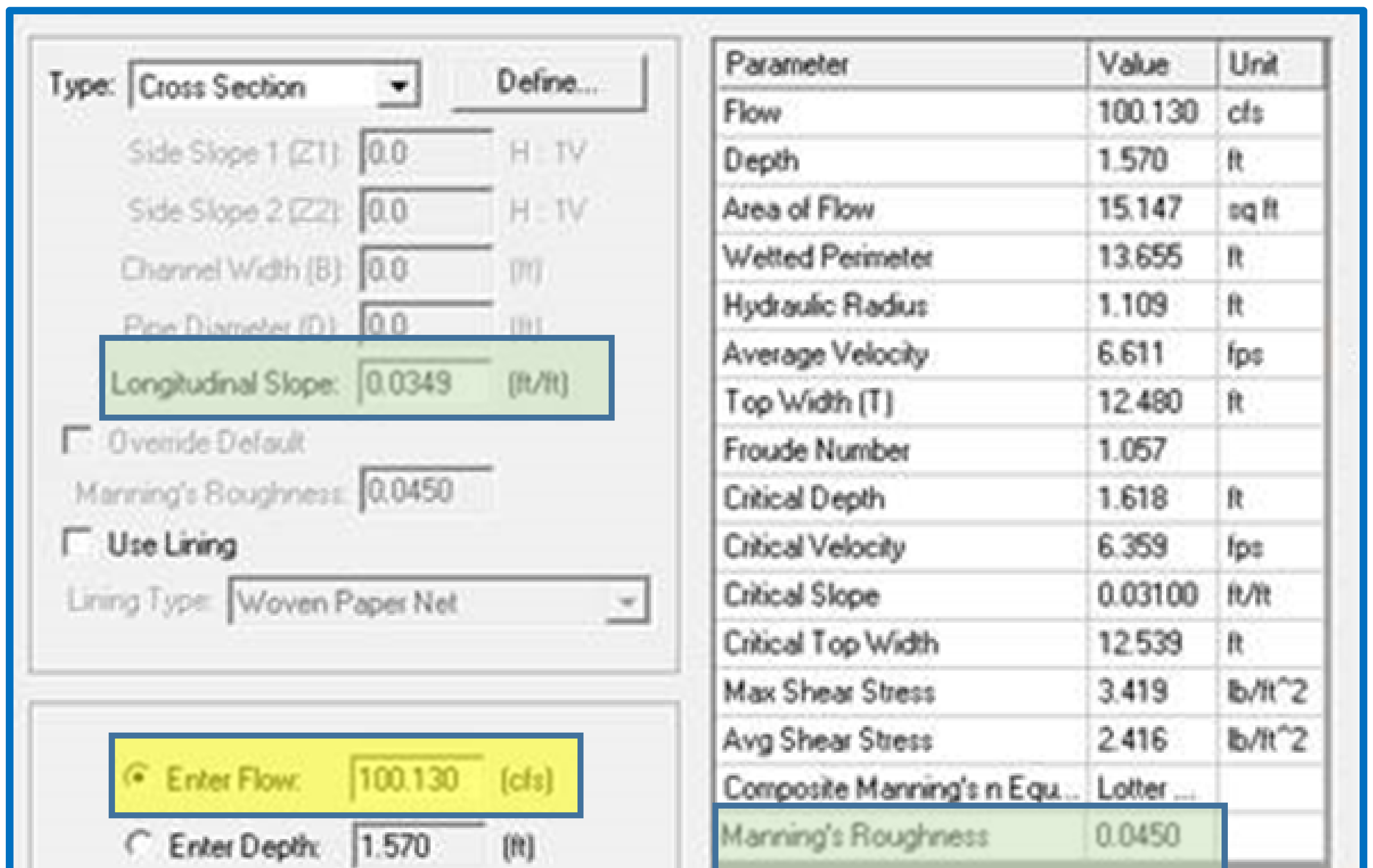
## Preliminary Design Phase – Hydraulic Modeling

# USGS Regression Method - flow

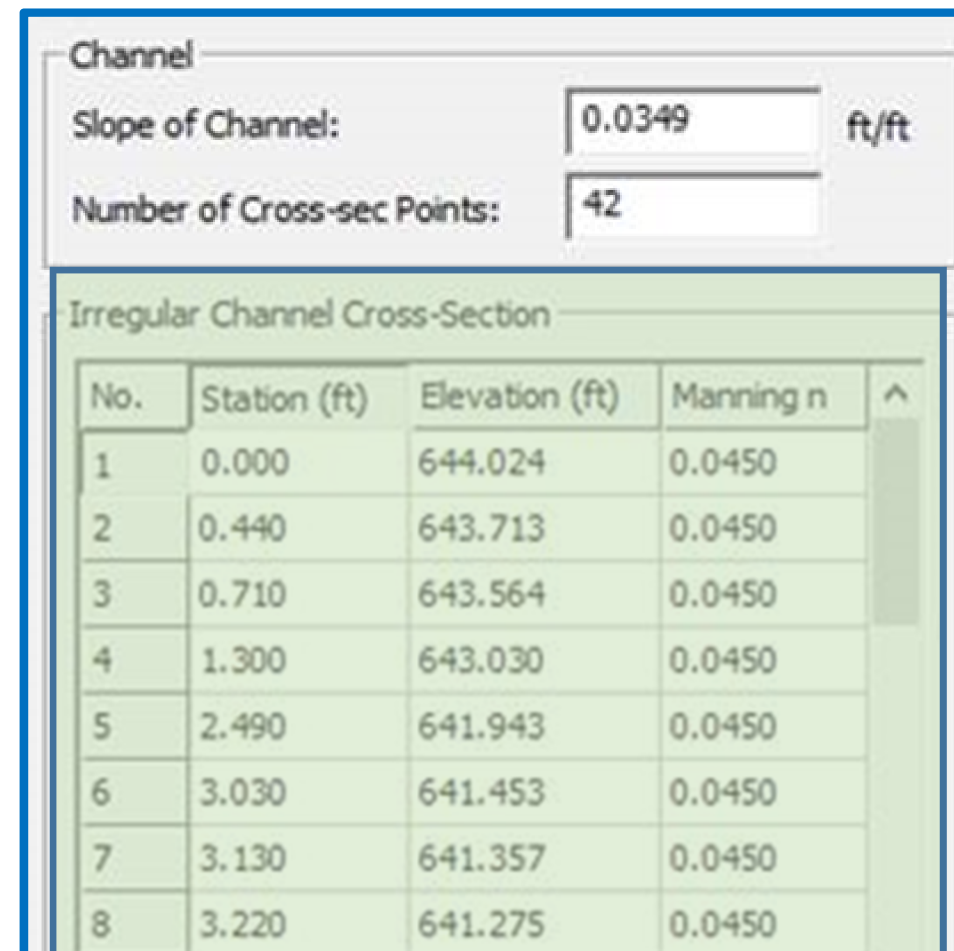


# Example – Hydraulic Toolbox

## Inputs: 1.5-yr flow + channel characteristics (slope, cross section, n)




| Parameter | Value | Unit |
|---|---|---|
| Flow | 100.130 | cfs |
| Depth | 1.570 | ft |
| Area of Flow | 15.147 | sq ft |
| Wetted Perimeter | 13.655 | ft |
| Hydraulic Radius | 1.109 | ft |
| Average Velocity | 6.611 | fps |
| Top Width (T) | 12.480 | ft |
| Froude Number | 1.057 | |
| Critical Depth | 1.618 | ft |
| Critical Velocity | 6.359 | fps |
| Critical Slope | 0.03100 | ft/ft |
| Critical Top Width | 12.539 | ft |
| Max Shear Stress | 3.419 | lb/ft^2 |
| Avg Shear Stress | 2.416 | lb/ft^2 |
| Composite Manning's n Equ... | Lotter ... | |
| Manning's Roughness | 0.0450 | |

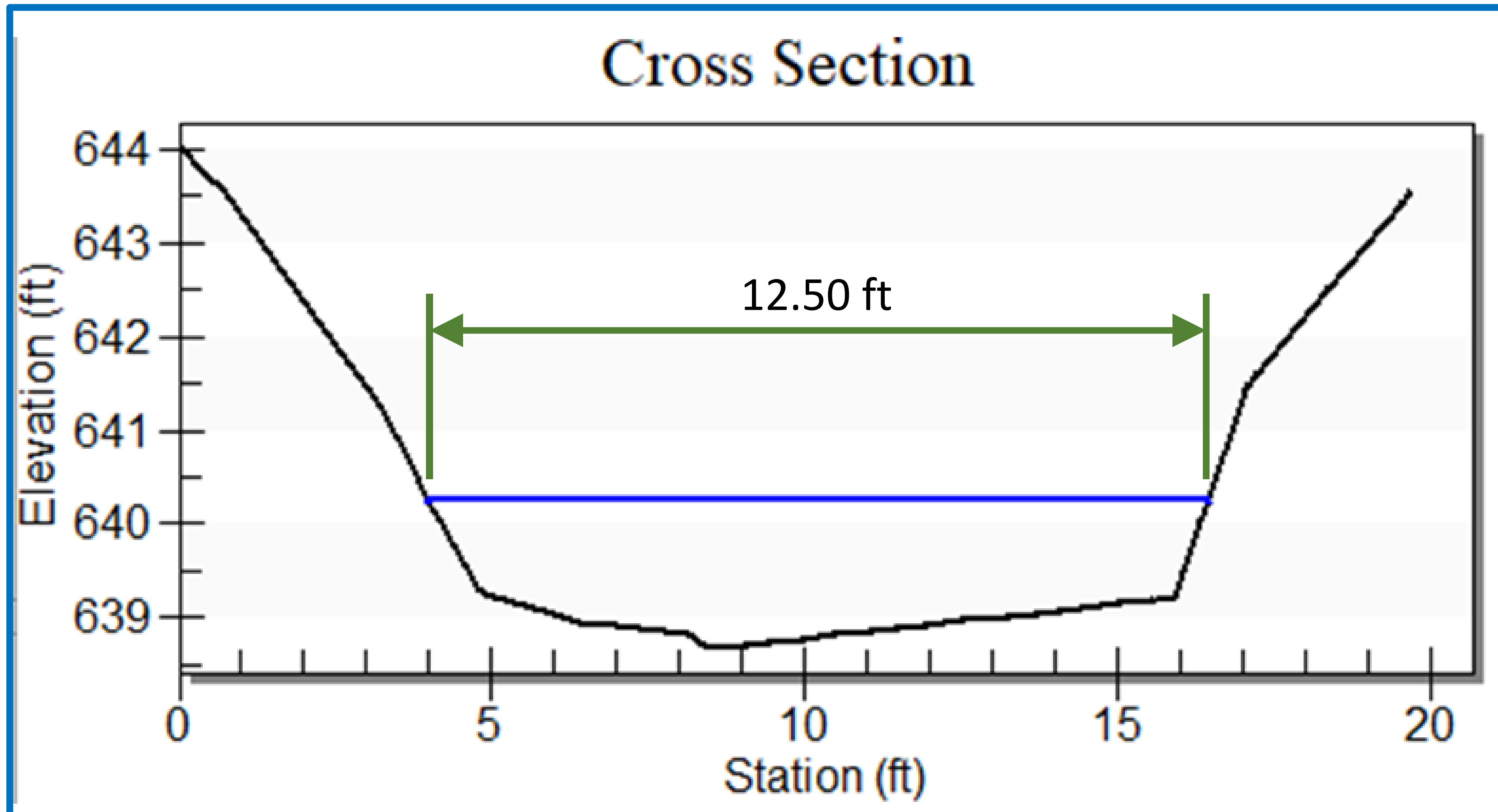



| No. | Station (ft) | Elevation (ft) | Manning n |
|---|---|---|---|
| 1 | 0.000 | 644.024 | 0.0450 |
| 2 | 0.440 | 643.713 | 0.0450 |
| 3 | 0.710 | 643.564 | 0.0450 |
| 4 | 1.300 | 643.030 | 0.0450 |
| 5 | 2.490 | 641.943 | 0.0450 |
| 6 | 3.030 | 641.453 | 0.0450 |
| 7 | 3.130 | 641.357 | 0.0450 |
| 8 | 3.220 | 641.275 | 0.0450 |

# Example – Hydraulic Toolbox

## Results: bankfull width

| Parameter | Value | Unit |
|---|---|---|
| Flow | 100.130 | cfs |
| Depth | 1.570 | ft |
| Area of Flow | 15.147 | sq ft |
| Wetted Perimeter | 13.655 | ft |
| Hydraulic Radius | 1.109 | ft |
| Average Velocity | 6.611 | fps |
| Top Width (T) | 12.480 | ft |
| Froude Number | 1.057 | |
| Critical Depth | 1.618 | ft |
| Critical Velocity | 6.359 | fps |
| Critical Slope | 0.03100 | ft/ft |
| Critical Top Width | 12.539 | ft |
| Max Shear Stress | 3.419 | lb/ft^2 |
| Avg Shear Stress | 2.416 | lb/ft^2 |
| Composite Manning's n Equ... | Lotter ... | |
| Manning's Roughness | 0.0450 | |



# Preliminary Design Phase

## Selection of bankfull width → Culvert width

- Bankfull data sources:
  1. Ecologist field measurement → Primary metric
  2. Hydraulic modeling → Additional metric
  3. Regional curve equations → Additional metric
- Considerations:
  - Bankfull width is a "fuzzy" number / concept
    - Recognize imprecise nature & methodology limitations
    - Reasoned determination supported by combination of methods above → SUCCESS

## Preliminary Design Phase

### Selection of bankfull width → Culvert width

- Considerations, cont.:
  - Culvert width >= bankfull width
  - GDOT box culvert widths:
    - 4’ – 10’ (single, double, triple)
    - Single barrel: 4’ 5’ 6’ 7’ 8’ 9’ 10’
    - Double barrel: 8’ 10’ 12’ 14’ 16’ 18’ 20’
    - Triple barrel: 12’ 15’ 18’ 21’ 24’ 27’ 30’
    - Disregard width of wall between barrels
      - e.g. a double 7’ x 7’ is considered to be 14’ wide

# Preliminary Design Phase

**Culvert Design – Reminder:** **A complete 1~~8~~0° → 90°**

- Project team agrees on bankfull width (e.g. 7.5 ft)
- Culvert width equal to or slightly greater than bankfull (e.g. 8 ft)
- Store existing stream horizontal alignment & cut profile
  - What is the average existing stream grade?
- Lay out (iterate) horizontal alignment of proposed culvert
- Lay out (iterate) vertical alignment of proposed culvert
  - See regional conditions for limitations on culvert grade
- Tie in proposed culvert to existing stream
  - Culvert itself
  - Channel excavation

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# Preliminary Design Phase

**Culvert Design – Reminder:** **A complete $1\cancel{8}0^{\circ} \rightarrow 90^{\circ}$**

- Sharpen your pencil:
  - Look at existing stream contours
  - Visualize design in 3D
  - Consider different horizontal tie-in locations
    - Would a slight culvert extension or channel excavation provide a better tie-in to the stream?
- Plan presentation reminder:
  - Getting the size and alignment of the culvert is critical
  - Reflecting this design can still be a challenge

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# Outline

**Context & engineer's mindset**

- Application / scope / Plan Development Process
- A complete ~~180º~~ → 90º

**Engineer's responsibilities**

- Begin with the end in mind
- Environmental coordination
  - o Bankfull – regional curve equations
- Culvert design
  - o Bankfull – hydraulic modeling
  - o Selection of bankfull width → culvert width
  - o Culvert design
- **Documentation & plan production**
  - o **Perennial stream culvert diagrams (39-series plans)**

Concept Phase

Preliminary Design Phase

Final Design Phase

# Final Design Phase

## Documentation & Plan Production (Final phase)

- Environmental lock-down plans
- 404 permit application
  - Existing culvert extensions:
    - Narrative on data collection & decision making (ecologist)
    - Typical plan (13-series) and cross section view (22-series)
  - New & replacement culverts:
    - Perennial stream diagrams (39-series plans)

# Final Design Phase

## Designer’s Perspective

## Plan Production

- Objective = convey design intent to audience
- Guidance:
  - Perennial Stream Culvert Diagram Guidance
  - ROADS → Design & Environmental Coordination

**Roadway**

| Title | Revised | Contact |
|---|---|---|
| Category : Construction Stormwater (Erosion Control) | | |
| Category : Design & Environmental Coordination Guidance | | |
| Ecology Post Construction Stormwater Report Template | 7/9/2021 | Brad McManus |
| Environmental Survey Boundary Guidance | 9/13/2019 | Sam Woods |
| Local Coordination Procedure | 10/22/2019 | Gail D'Avino |
| Category : Design Policy | | |

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# Final Design Phase

## Designer's Perspective – Plan production "PPG"

**Section 39** Perennial Stream Crossing Details

**39.001 General**

Perennial Stream Crossing Detail sheets should be developed through coordination between the roadway/hydraulics engineers and ecologists. Once finalized, these sheets are provided to the project ecology team for their use in permit applications.

**39.002 Required Information**

For each perennial stream culvert a series of plan sheets/diagram are required:

- **Plan view diagram of the existing and proposed conditions**
  - Information shown on a typical 13-series construction plan sheet including:
    - Legend, Scale, North arrow
    - Roadway items (alignments, edges of pavement, curb and gutter, sidewalk, shoulders, driveways, guardrail/barriers, etc.)
    - Drainage items (including ditches, storm drain pipes, and culverts with structure number, flow arrow, and size labels)
    - Post-Construction Stormwater BMPs
    - Property lines with labels
    - Existing right-of-way and easement lines with labels
    - Proposed right-of-way and easement lines with labels
    - Construction limits (cut/fill lines with designations)
    - All ESAs including, but not limited to, state buffers, wetland boundaries, historical boundaries, T&E habitats, archaeological resources, hazardous materials, environmental justice areas, and streams (with labels)
    - Orange Barrier Fence
    - Retaining walls
    - Noise Barriers
    - Bridges
  - Additional information shown only on the 39-series plan view:
    - Stream flow direction indicated by arrows
    - Stream horizontal alignment (including stationing and tick marks):
      - Stationing should increase in the downstream direction
      - Alignment should match the surveyed stream
      - Alignment should ideally cover the extents of the surveyed stream or plan sheet coverage (whichever is smaller).
      - At a minimum, alignment should cover the stream length from approximately 100-ft upstream of the proposed culvert inlet to approximately 100-ft downstream of the proposed culvert outlet
    - Callouts indicating the location and station of stream cross sections shown on later sheets.

- **Longitudinal profile diagram of the existing stream channel**
  - Existing stream profile
    - Even stations and existing ground elevations every 50 feet along stream alignment
    - Average streambed slope should be noted
    - Callouts indicating the location of the proposed culvert inlet and outlet
    - Callouts indicating the location and station of stream representative cross section(s) and proposed culvert inlet and outlet cross sections shown on later sheets.

- **Longitudinal profile diagram of the proposed culvert**
  - Proposed culvert:
    - Structure number
    - Invert elevations
    - Length, size, flow direction, longitudinal slope, embedment depth
    - Number of barrels
  - Proposed energy dissipation/outlet protection:
    - Ensure rip rap for energy dissipation is properly reflected graphically (top of rip rap flush with top of ground)
  - Proposed channel excavation (if required)
  - Callouts indicating the location and station of the proposed culvert inlet and outlet cross sections shown on later sheets.

- **Representative cross-section diagram(s) of the existing stream channel**
  - Existing ground showing cross section view of stream channel bed and banks
  - Bankfull width and cross-sectional area:
    - Bankfull width should be shown graphically by a horizontal line within the stream channel
    - The corresponding width measurement should be shown (feet)
    - The bankfull cross-sectional area (square feet) value should be shown
      - Area bounded by the horizontal bankfull elevation line on the top, and bounded by the existing stream channel on the bottom and sides (see diagram below)
  - Flood prone "area":
    - Flood prone "area" should be shown graphically by a horizontal line within the stream channel, at a depth twice the bankfull depth (see diagram below)
      - Flood prone elevation = stream bottom elevation + (2 * bankfull depth)

- **Cross-sectional diagrams of the proposed culvert inlet and outlet**
  - Callouts for culvert size and type
  - Proposed road surface and areas of cut and fill
  - Proposed culvert invert elevation (embedded, if applicable)
  - Baffles with elevation labelled, if applicable
  - Existing stream channel with stream bottom elevation label
  - Bankfull width and flood prone "area" as noted above
  - Proposed bankfull cross-sectional area (square feet) value should be shown
    - Area bounded by the horizontal bankfull elevation line on the top, bounded by the existing stream bottom elevation on the bottom, and bounded by the proposed culvert on the sides (see diagram below)

**39.003 Drawing Layout**

For each new or replaced culvert at a perennial stream, a series of plan sheets (plan, profile, and cross sections) are required as described above.

**Sequence:**

Plan sheets should be grouped so that all relevant sheets for a specific culvert are numbered sequentially. Separate crossing locations should be organized with respect to the 13-series plan sheet conventions (begin project to end project). For example, if a project proposes two new or replaced culverts on perennial streams (PS-1 on sheet 13-05, and PS-2 on sheet 13-09), the 39-series plan sheet should be organized and presented accordingly:

- 39-0001: PS-1 Plan View
- 39-0002: PS-1 Longitudinal Profile View of existing stream channel
- 39-0003: PS-1 Longitudinal Profile View of proposed culvert
- 39-0004 to 39-0005: PS-1 Stream & culvert cross sections
- 39-0006: PS-2 Plan View
- 39-0007: PS-2 Longitudinal Profile View of existing stream channel
- 39-0008: PS-2 Longitudinal Profile View of proposed culvert
- 39-0009: PS-2 Stream & culvert cross sections

Please note that some of the view conventions above (profile vs. cross sections) differ from typical roadway plan conventions because the frame of reference is the perennial stream channel alignment instead of the roadway alignment.

**Size and Scale:**

All 39-series plan sheets should be generated using 11" x 17" paper size.

The plan view sheets scale should match the 13-series plan sheets.

The longitudinal stream profile sheet scale should be the maximized to fit on a single plan sheet horizontally. Vertical exaggeration of 5x should typically be used to improve clarity.

The longitudinal culvert profile sheet scale should match the 22-series sheets (typically not vertically exaggerated).

The stream and culvert cross sections scale should be maximized to the extent possible. No more than two cross sections should be shown on each cross section sheet. The horizontal and vertical scales should be the same (no vertical exaggeration should be applied).

# Final Design Phase

## Designer's Perspective – Plan production "PPG"

- Stream horizontal alignment (including stationing and tick marks):
  - Stationing should increase heading downstream
  - Alignment should match the surveyed stream centerline
  - Alignment should cover the extents of the surveyed stream, or plan sheet coverage, whichever is smaller

- **Longitudinal profile diagram of the existing stream channel**
  - Existing stream profile
    - Even stations and existing ground elevations every 50 feet along stream alignment
    - Average streambed slope should be noted
    - Callouts indicating the location of the proposed culvert inlet and outlet
    - Callouts indicating the location and station of stream representative cross section(s) and proposed culvert inlet and outlet cross sections shown on later sheets.

# Final Design Phase

## Designer's Perspective – Plan production "PPG"

- **Representative cross-section diagram(s) of the existing stream channel**
    - Existing ground showing cross section view of stream channel bed and banks
    - Bankfull width and cross-sectional area:
        - Bankfull width should be shown graphically by a horizontal line within the stream channel
        - The corresponding width measurement should be shown (feet)
        - The bankfull cross-sectional area (square feet) value should be shown
            - Area bounded by the horizontal bankfull elevation line on the top, and bounded by the existing stream channel on the bottom and sides (see diagram below)
    - Flood prone "area":
        - Flood prone "area" should be shown graphically by a horizontal line within the stream channel, at a depth twice the bankfull depth (see diagram below)
            - Flood prone elevation = stream bottom elevation + (2 * bankfull depth)

# Final Design Phase

## Designer's Perspective – Plan production "PPG"

- **Cross-sectional diagrams of the proposed culvert inlet and outlet**
  - Callouts for culvert size and type
  - Proposed road surface and areas of cut and fill
  - Proposed culvert invert elevation (embedded, if applicable)
  - Baffles with elevation labelled, if applicable
  - Existing stream channel with stream bottom elevation label
  - Bankfull width and flood prone "area" as noted above
  - Proposed bankfull cross-sectional area (square feet) value should be shown
    - Area bounded by the horizontal bankfull elevation line on the top, bounded by the existing stream bottom elevation on the bottom, and bounded by the proposed culvert on the sides (see diagram below)

# Final Design Phase

## Designer's Perspective

### Plan Production – "PPG"

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- 39-0009: PS-2 Stream & culvert cross sections

Please note that some of the view conventions above (profile vs. cross sections) differ from typical roadway plan conventions because the frame of reference is the perennial stream channel alignment instead of the roadway alignment.

# Designer's Perspective

## Plan Production – "PPG"

**Size and Scale:**

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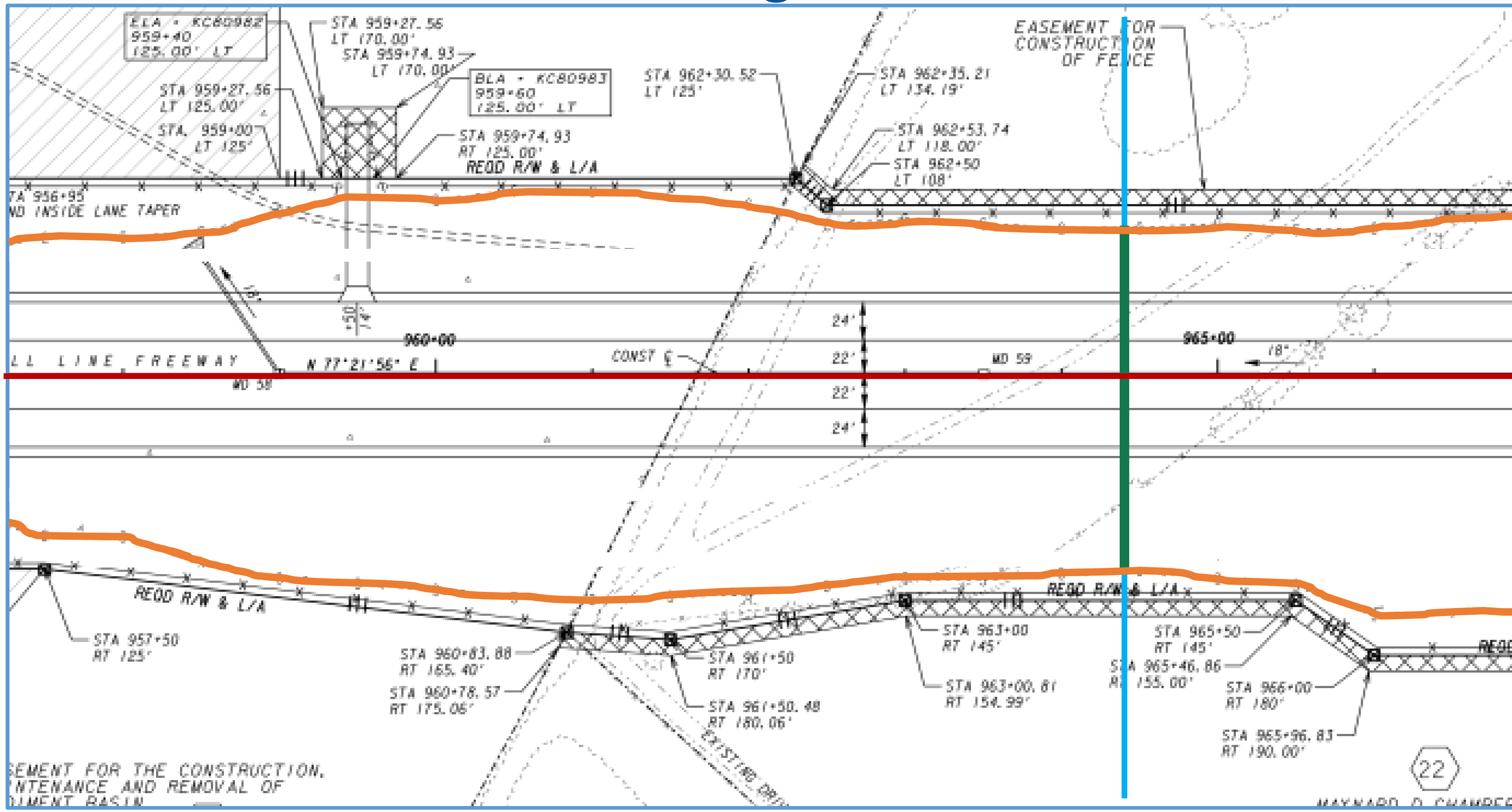
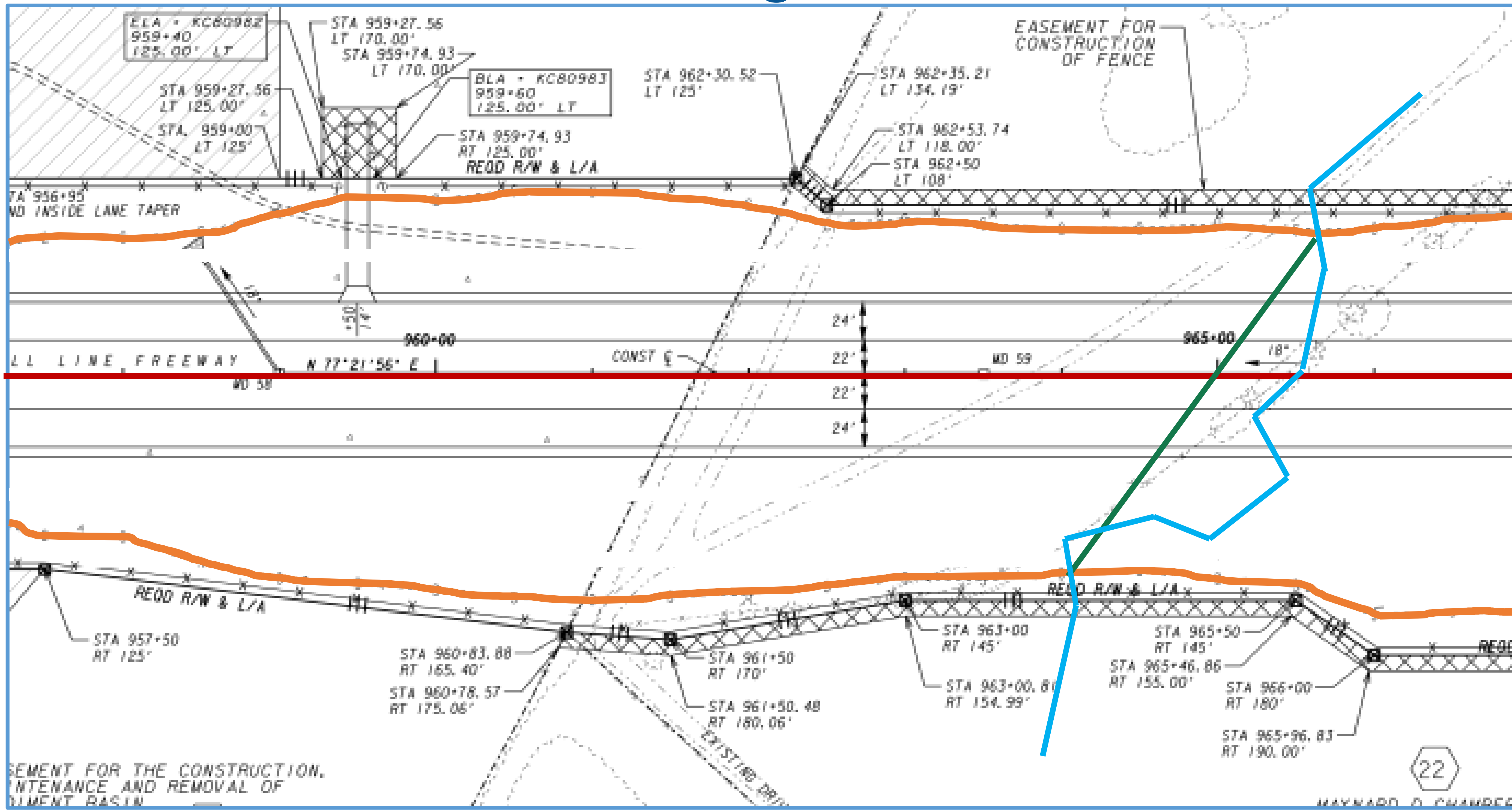
# Final Design Phase – Plan Presentation



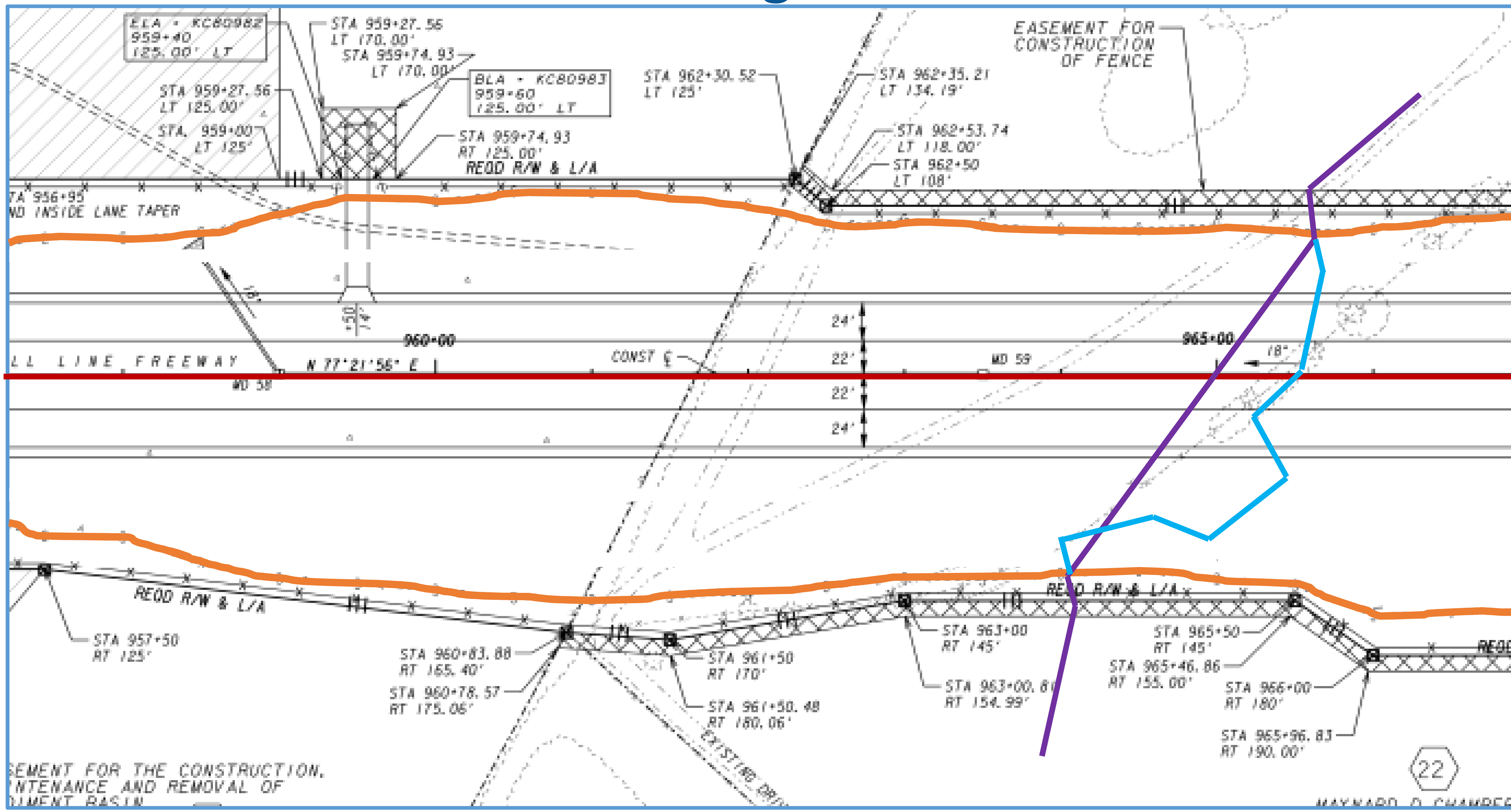

ROADWAY ALIGNMENT
CONSTRUCTION LIMITS (CUT/FILL)
STREAM ALIGNMENT
PROPOSED CULVERT

# Final Design Phase – Plan Presentation



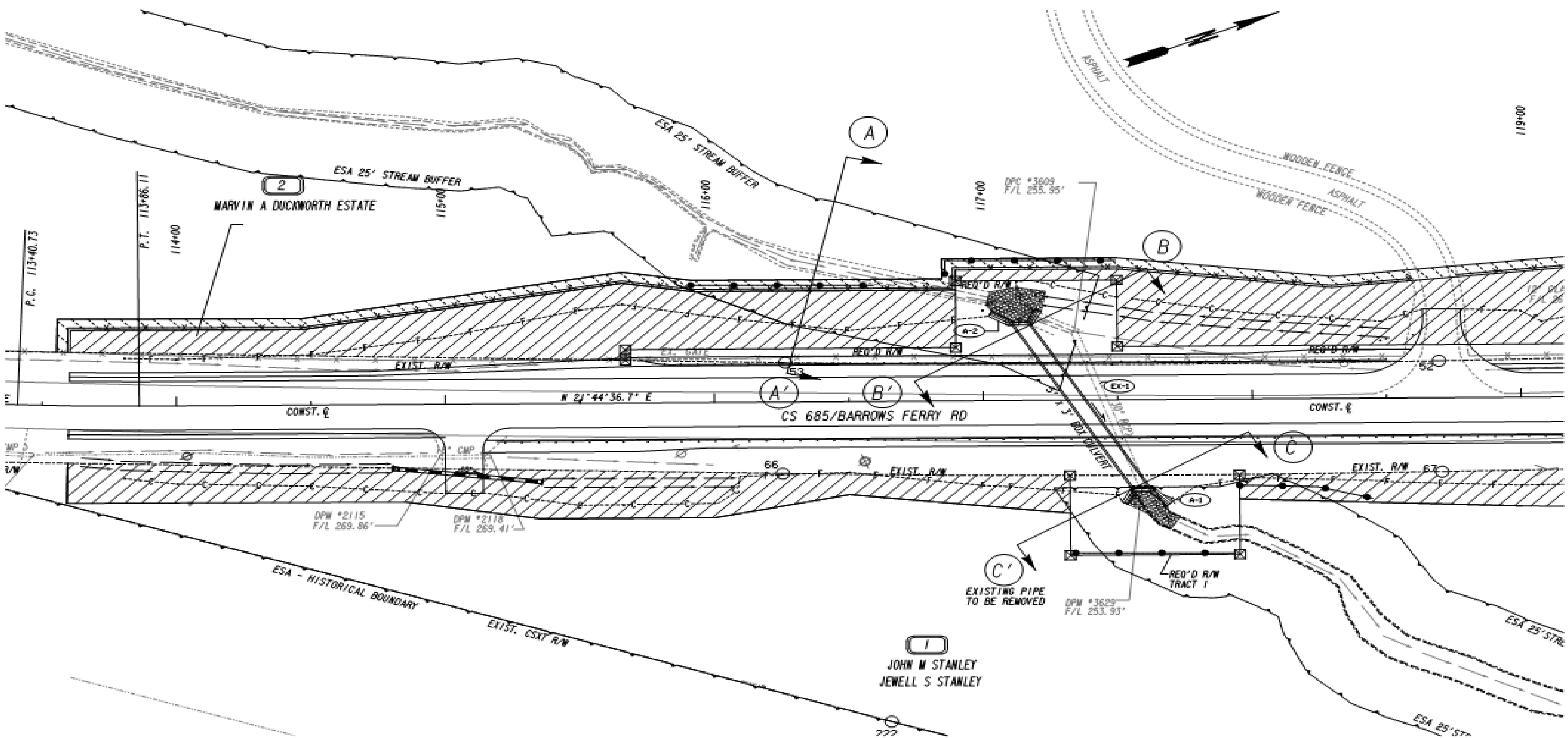

ROADWAY ALIGNMENT CONSTRUCTION LIMITS (CUT/FILL) STREAM ALIGNMENT PROPOSED CULVERT

# Final Design Phase – Plan Presentation

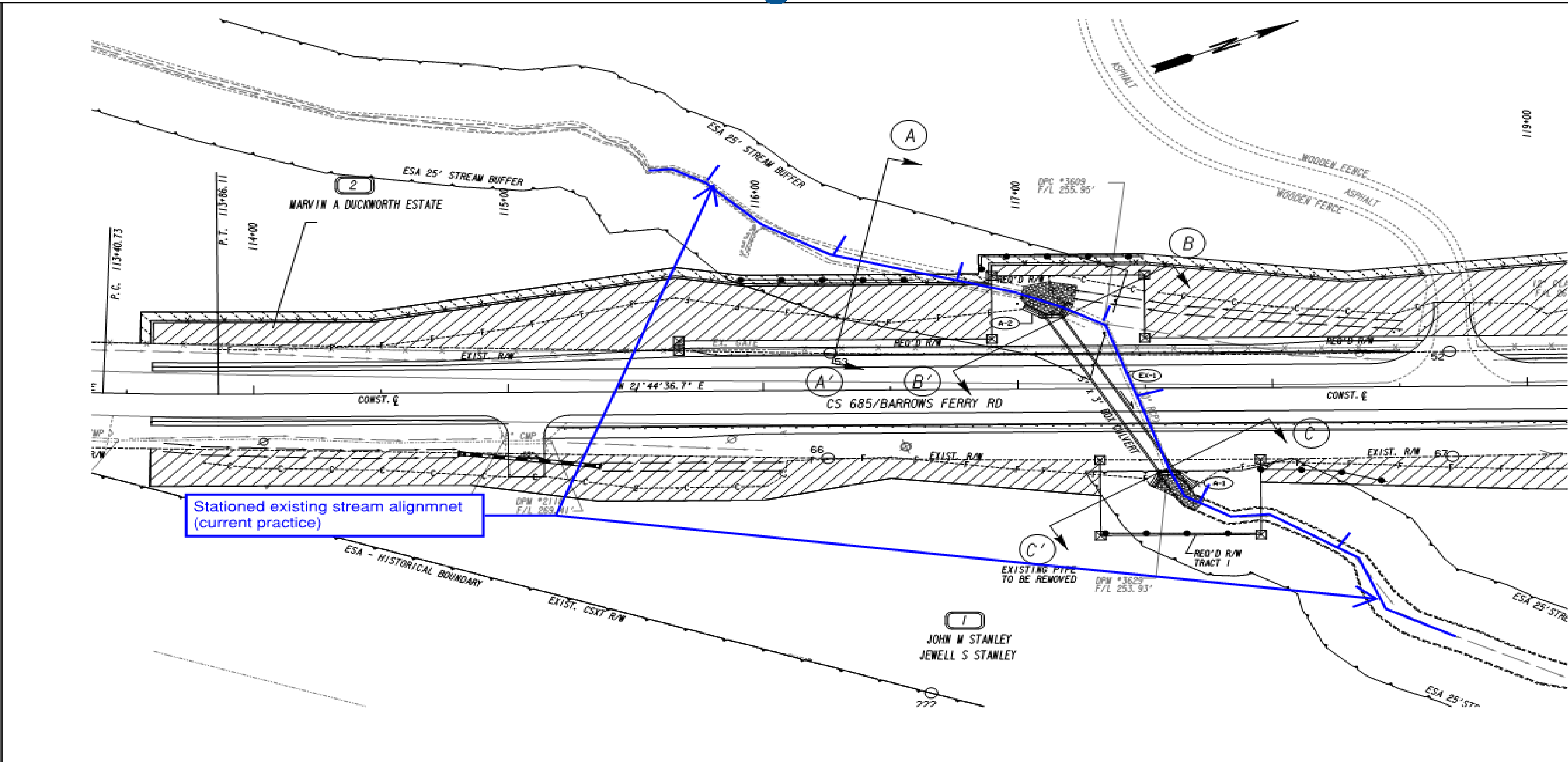



ROADWAY ALIGNMENT CONSTRUCTION LIMITS (CUT/FILL) PROPOSED COMBINED ALIGNMENT

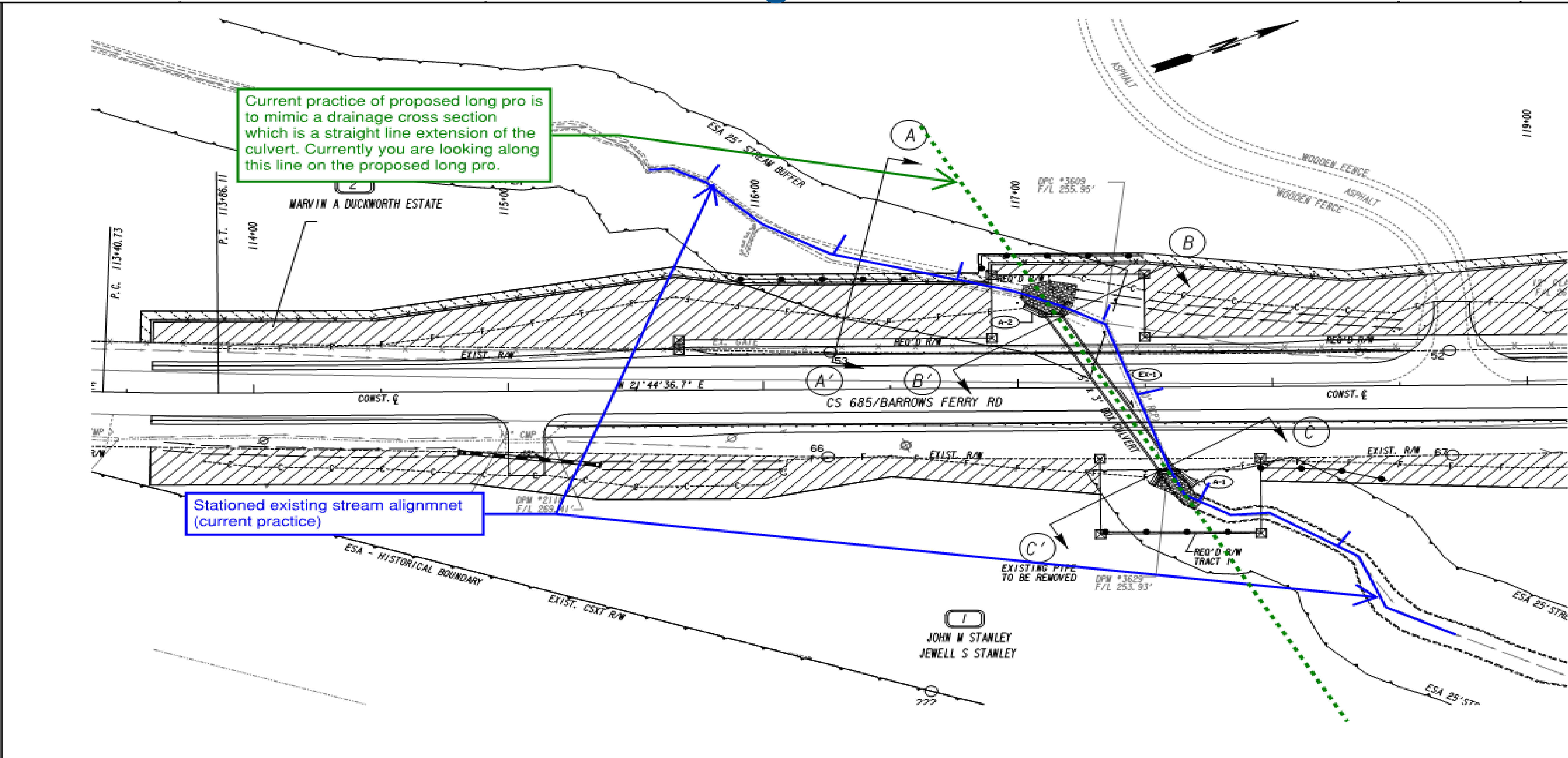
# Final Design Phase – Plan Presentation



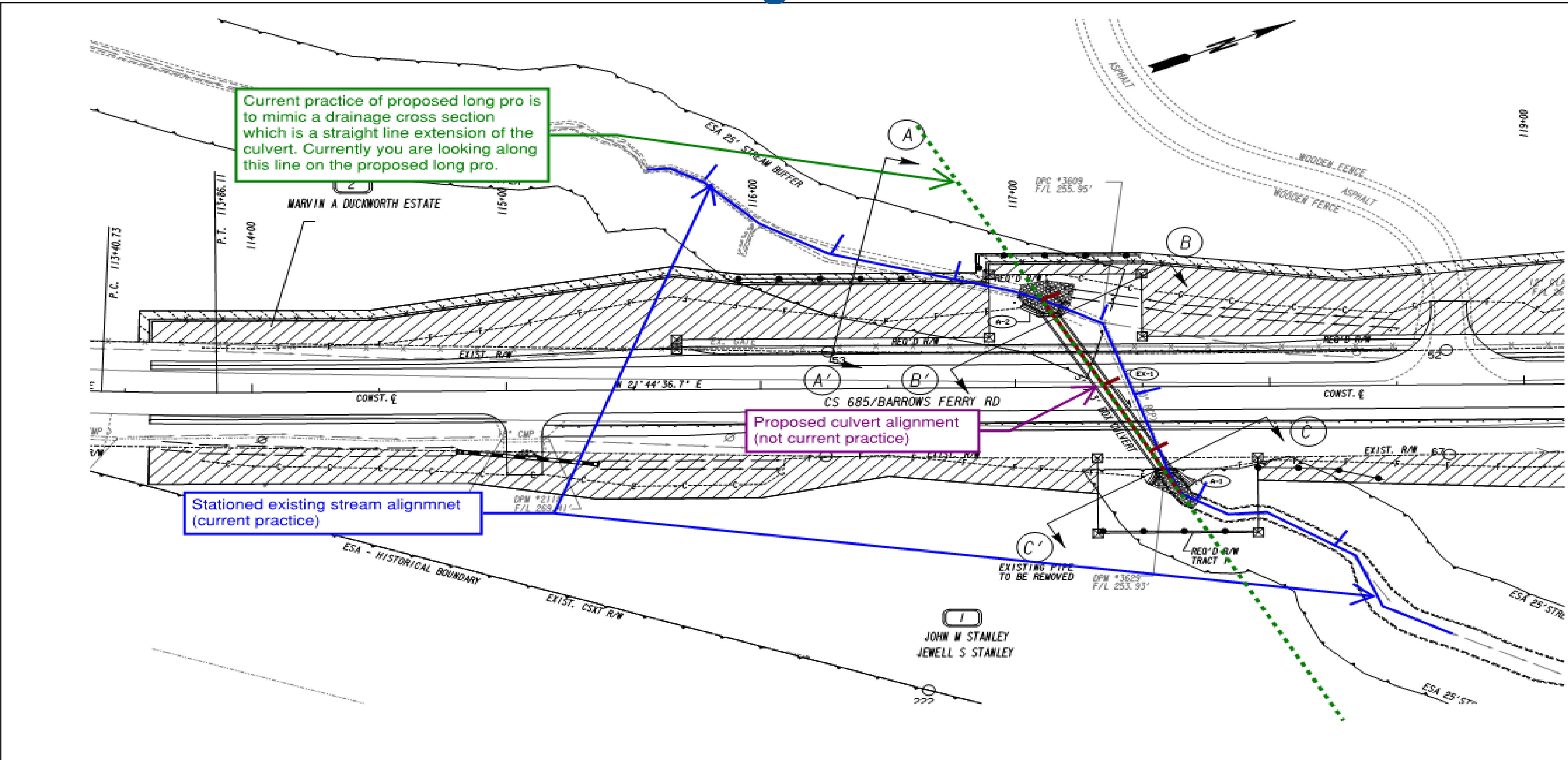
# Final Design Phase – Plan Presentation



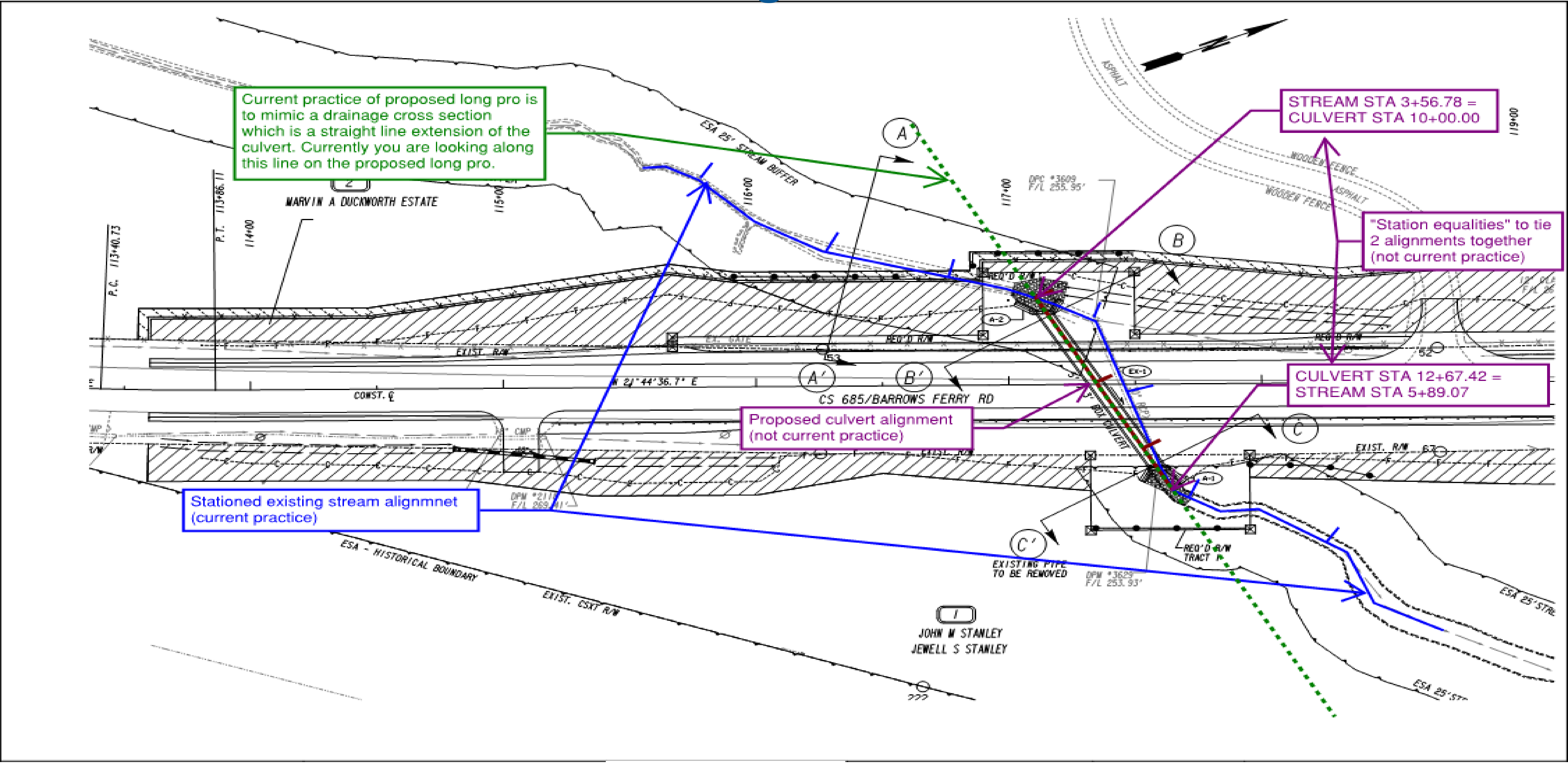
# Final Design Phase – Plan Presentation



# Final Design Phase – Plan Presentation



# Final Design Phase – Plan Presentation



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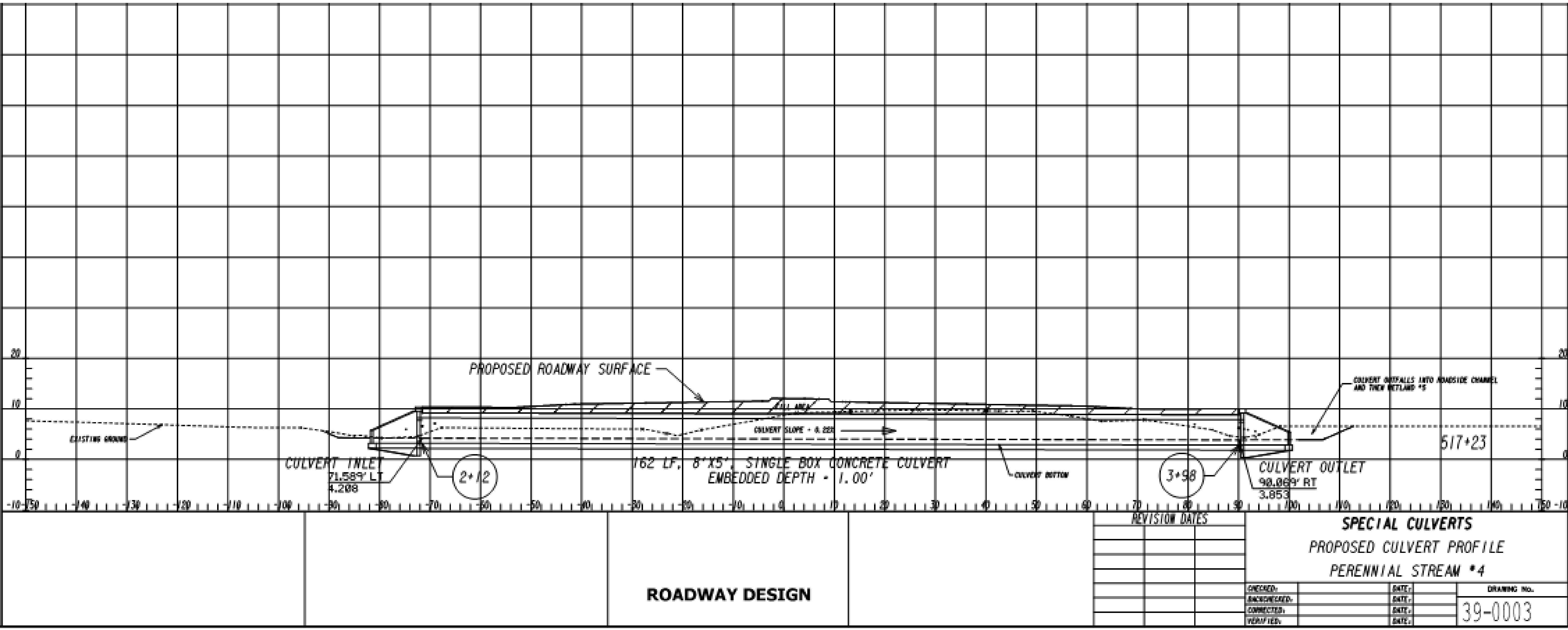

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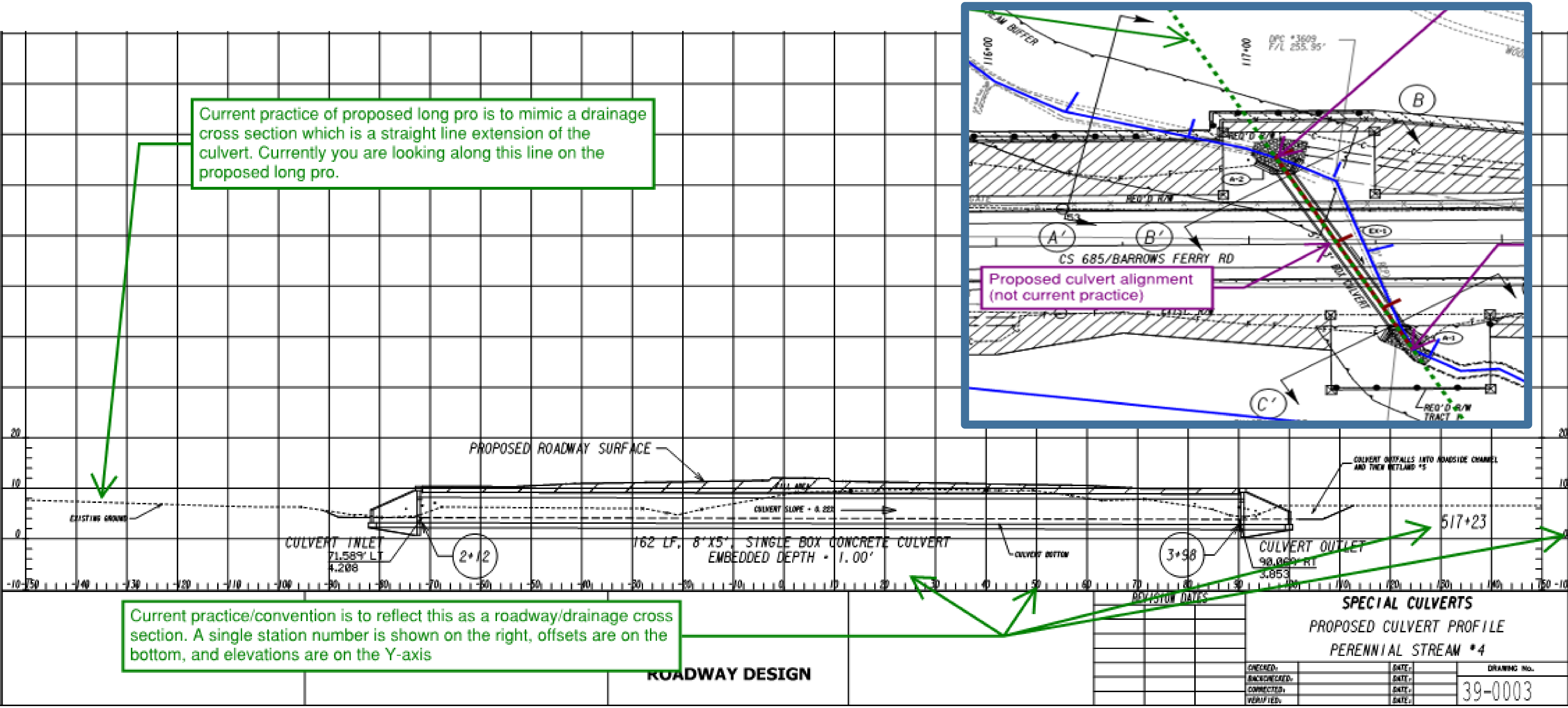
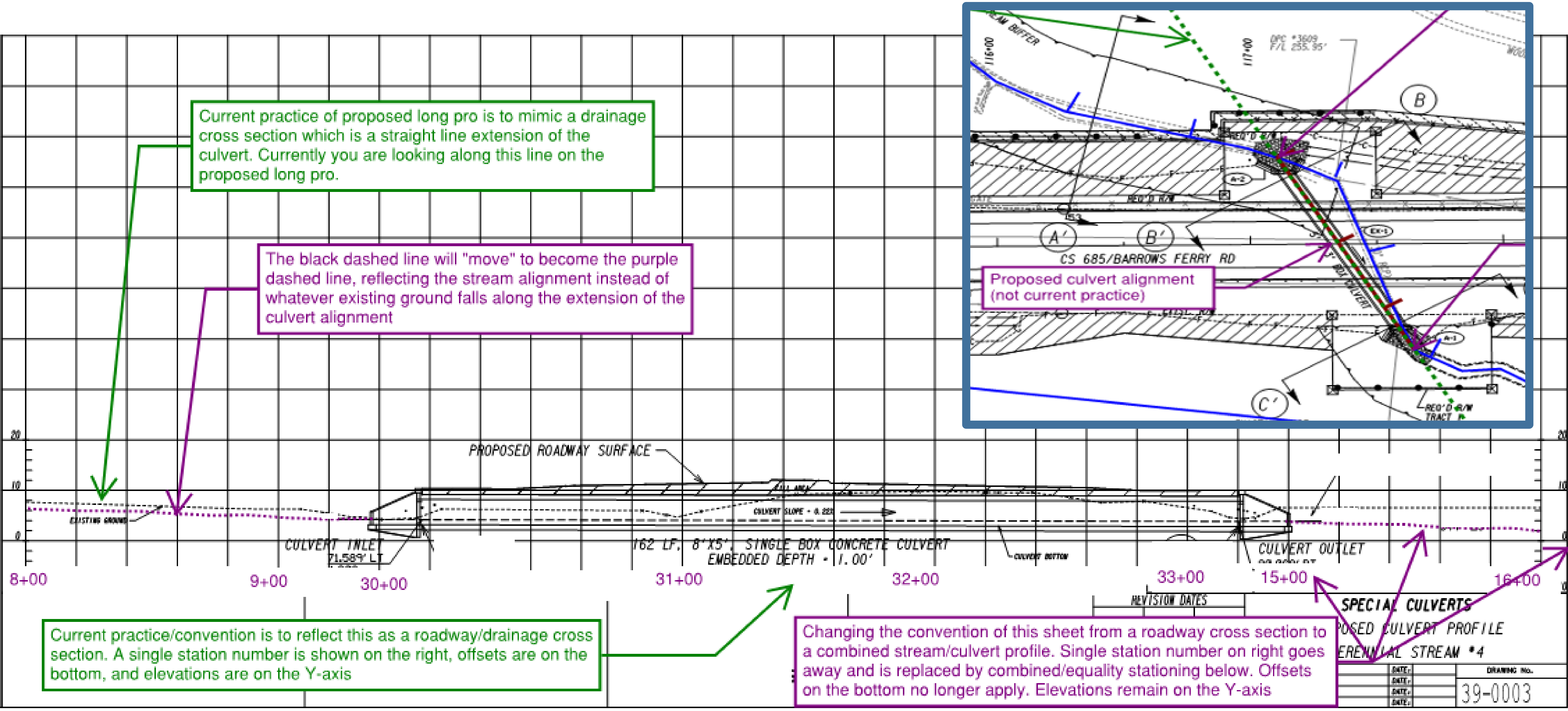


GDOT
Georgia Department of Transportation

# Final Design Phase – Plan Presentation




Current practice of proposed long pro is to mimic a drainage cross section which is a straight line extension of the culvert. Currently you are looking along this line on the proposed long pro.

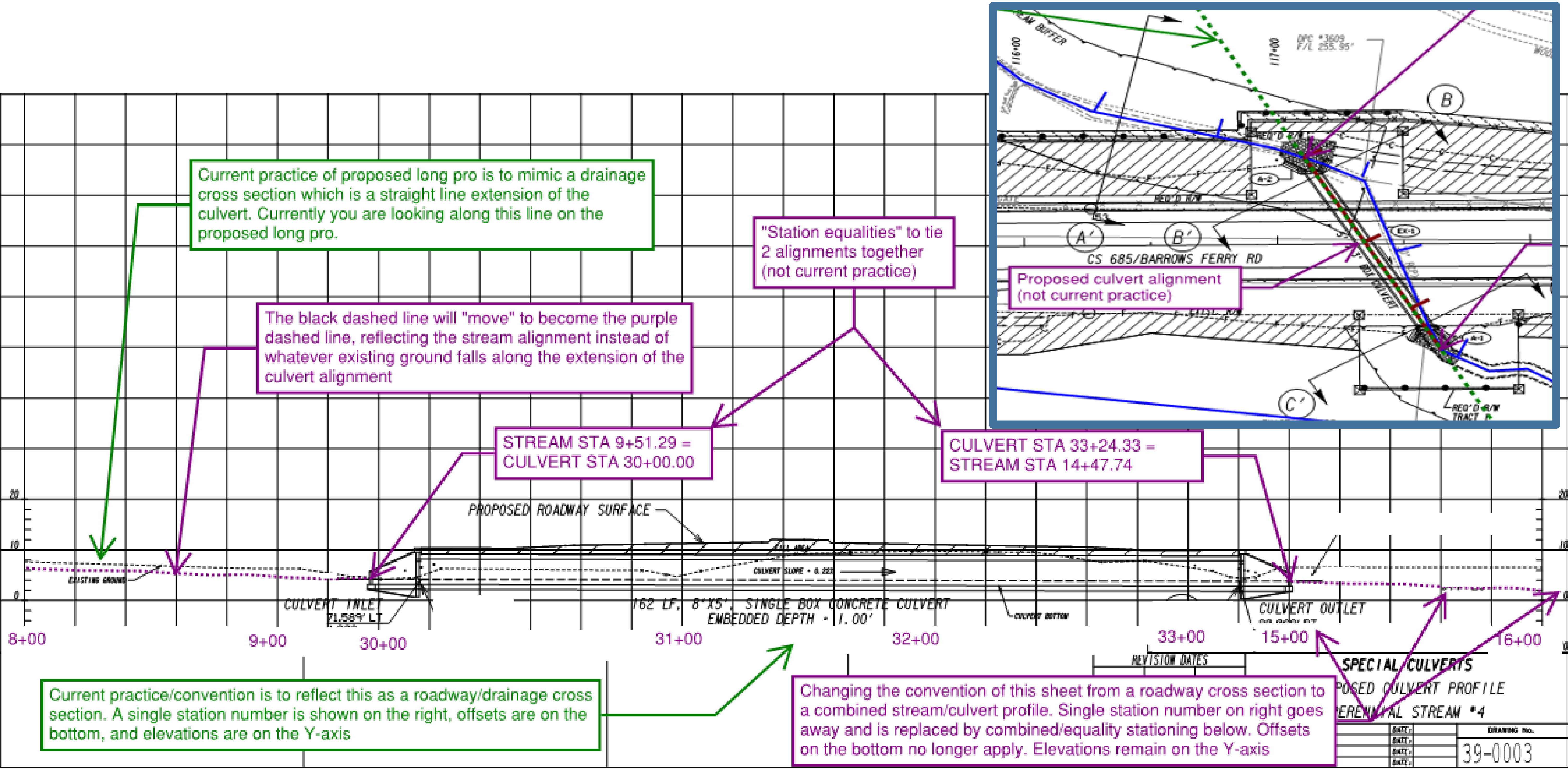
The black dashed line will "move" to become the purple dashed line, reflecting the stream alignment instead of whatever existing ground falls along the extension of the culvert alignment

Proposed culvert alignment (not current practice)

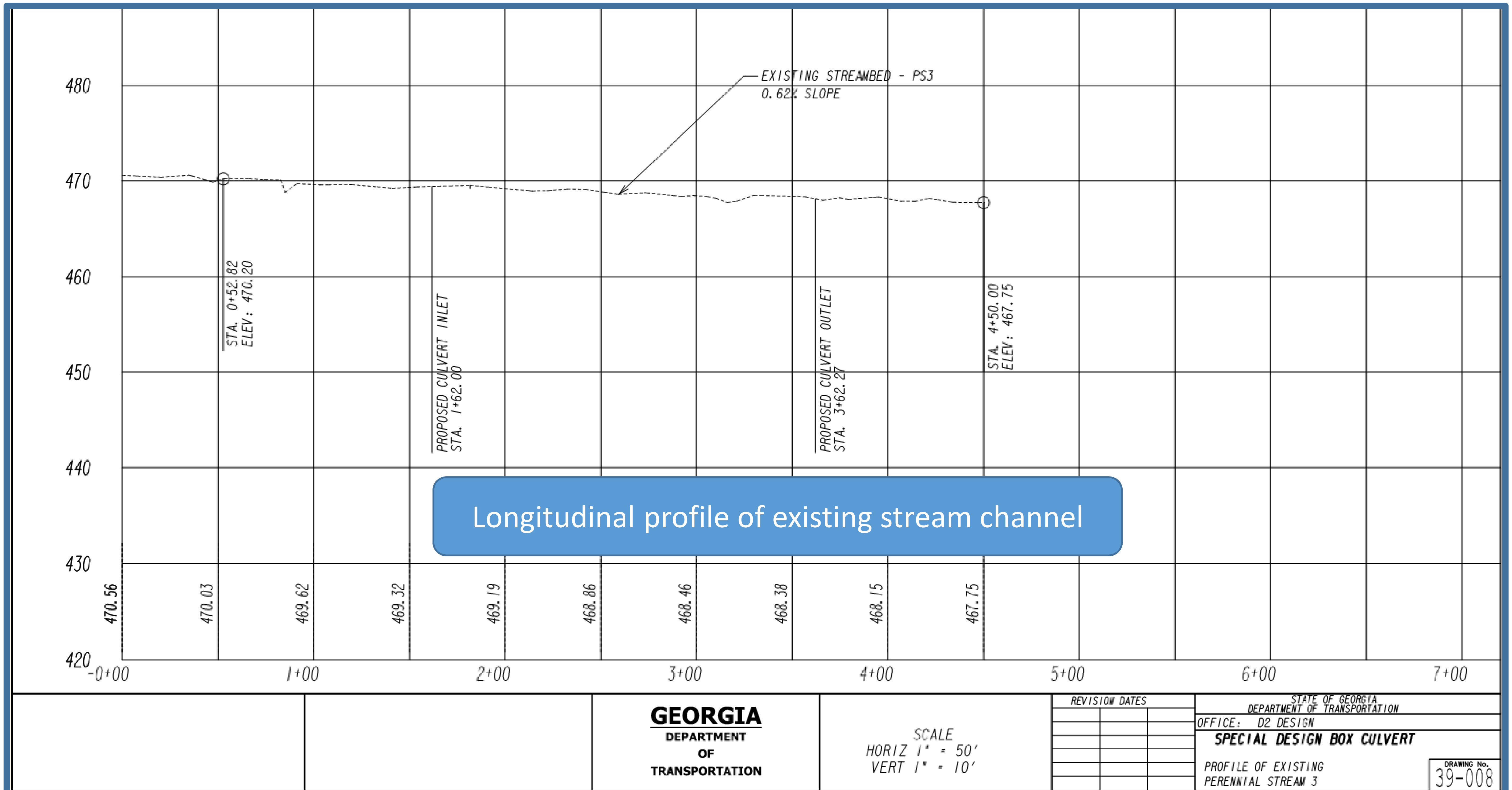
Current practice/convention is to reflect this as a roadway/drainage cross section. A single station number is shown on the right, offsets are on the bottom, and elevations are on the Y-axis

Changing the convention of this sheet from a roadway cross section to a combined stream/culvert profile. Single station number on right goes away and is replaced by combined/equality stationing below. Offsets on the bottom no longer apply. Elevations remain on the Y-axis

# Final Design Phase – Plan Presentation



# Final Design Phase – Plan Presentation



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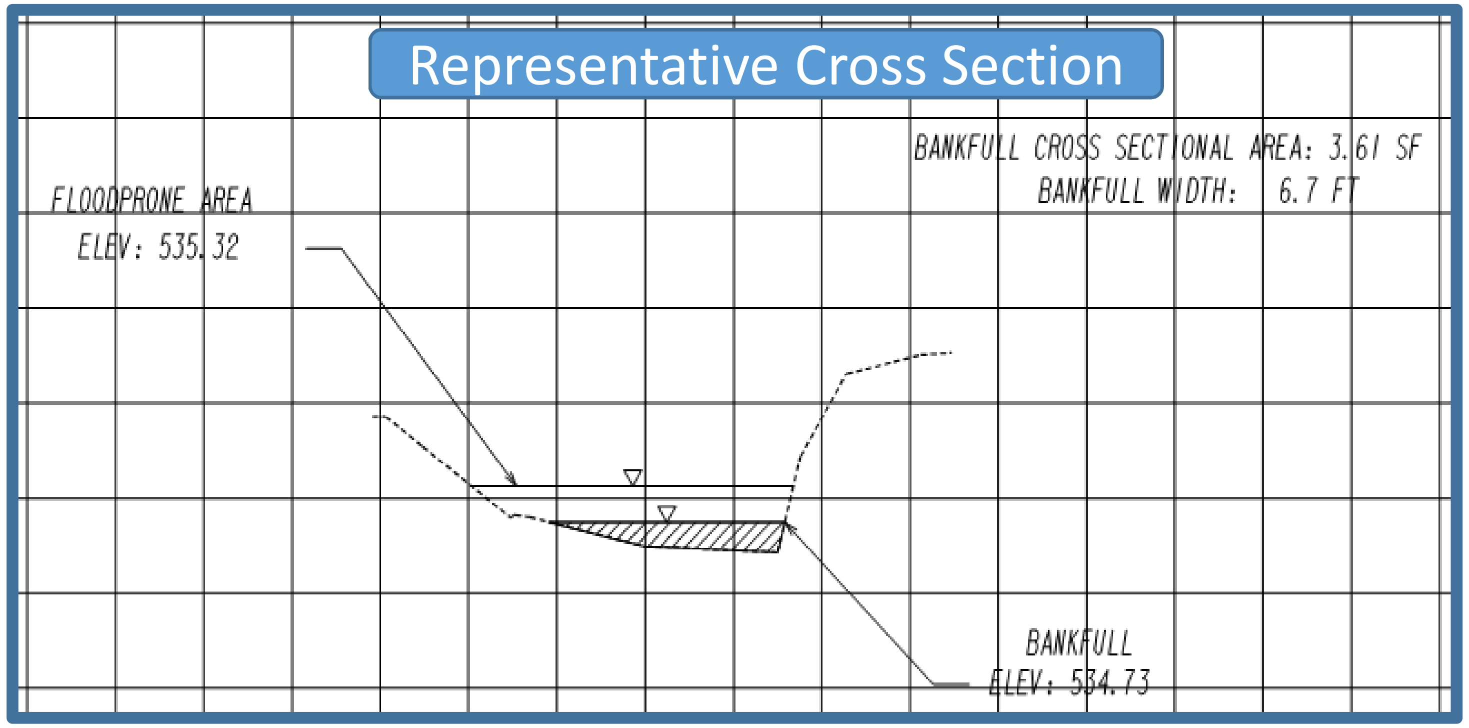
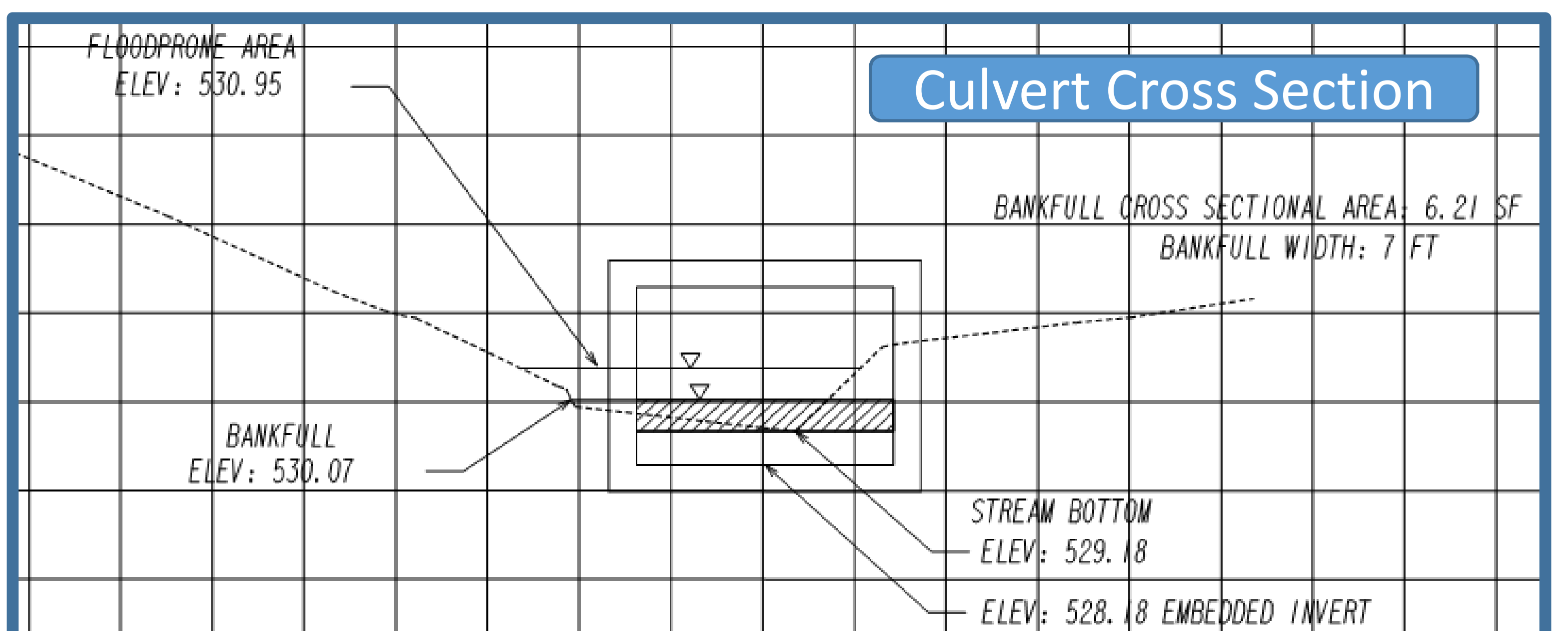
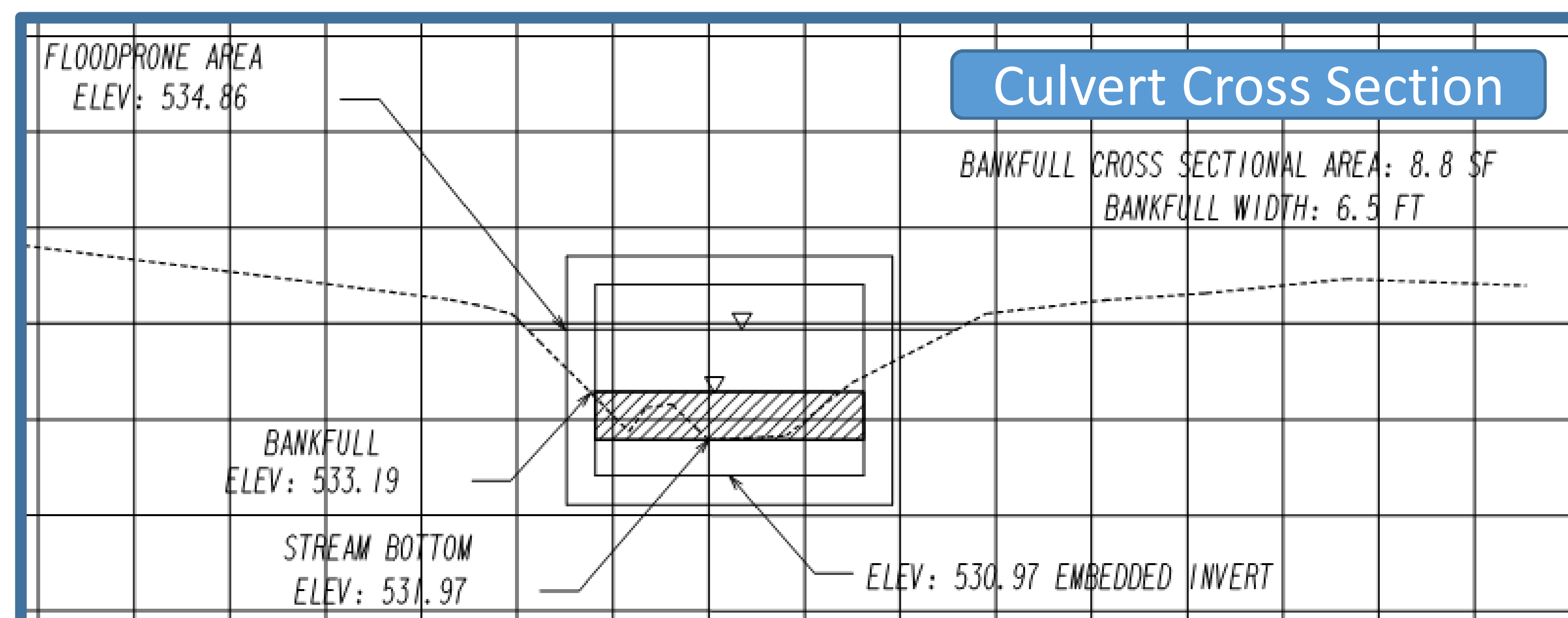


# Wrap-up and Key Takeaways

# Takeaways

## Perennial Stream Culverts – Engineer's Perspective

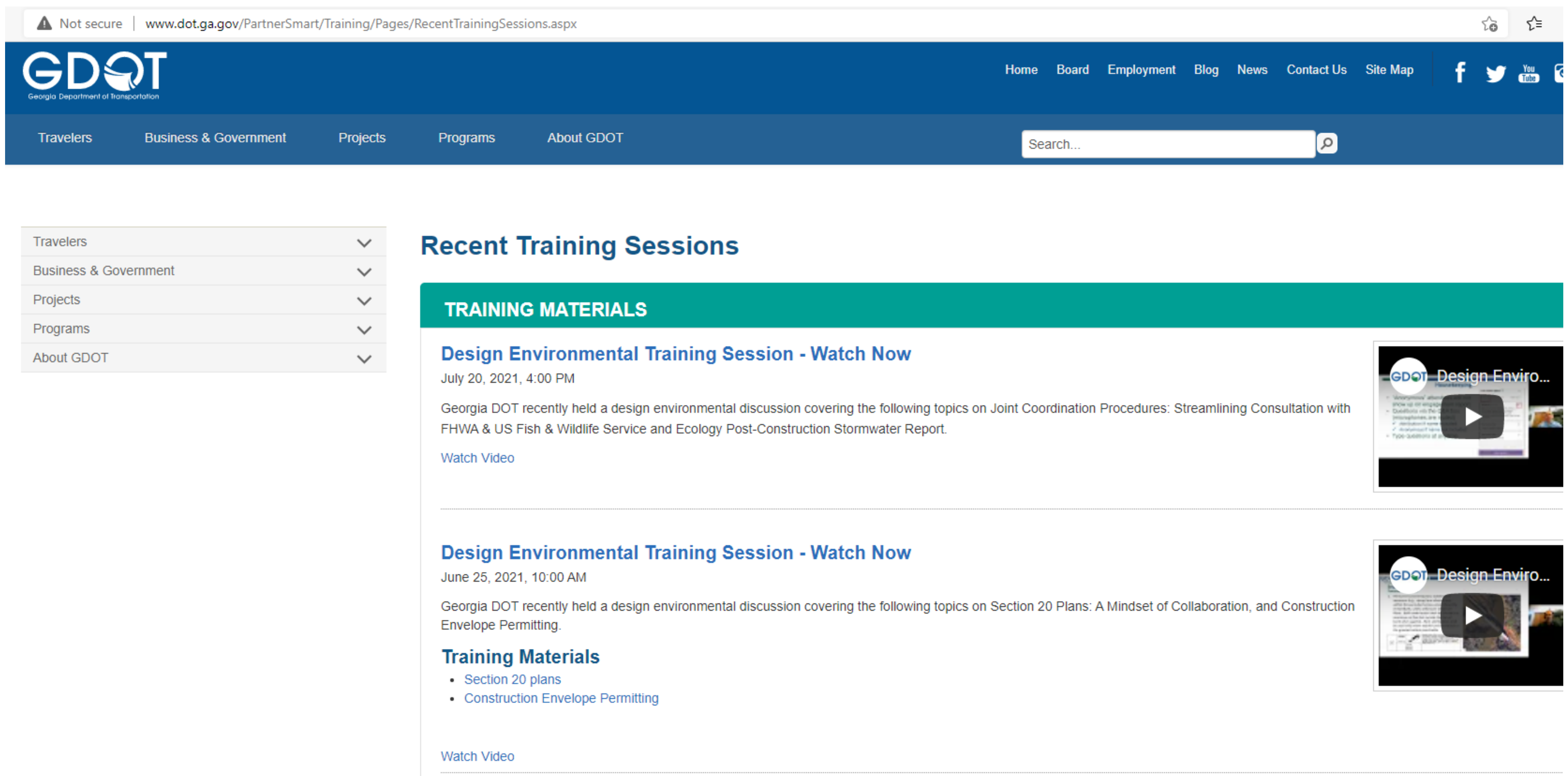
- Work proactively with your project ecologist and PM during from concept phase through the permit application phase
- Begin with the end in mind: culvert width >= bankfull, grade, & embedment
- Bankfull storm event to use in Georgia = 1.5-year storm
- Change your mindset and approach from designing a roadway cross section/culvert to designing a proposed stream profile
- Sharpen your pencil to get the design right & tight in preliminary design
- Requirements to comply with permit requirements are in addition to other criteria from GDOT and other agencies such as FEMA
- Utilize upcoming Perennial Stream Culvert Diagrams guidance for preparation of 39-series plans
- Remain positive, proactive, and focused during ecologist review and comment period on the culvert diagrams


QUESTIONS?

# Recent Training Webpage

Link to recent training on-line

**http://www.dot.ga.gov/PS/Training/RecentTraining**



# Recently Posted!

**Wednesday, June 23**

**Section 20 Plans:  A Mindset of Collaboration**

Donn Digamon, PE,  State Bridge Engineer
Sam Woods, PE, Assistant State Roadway Design Engineer
Chris Goodson, Ecology Section Manager

- *The connectivity of constructability and permits*
- *Project schedules and timeliness of Constructability and Final Plans Development phases*
- *How each team member contributes to the Section 20 process and plans*

**Construction Envelope Permitting**

Dave Hedeen, Ecology Section Manager

- *The concept of Construction Envelope Permitting (CEP)*
- *The application and limitations of the CEP concept*
- *How design changes and post-let changes may be addressed by CEP*
- *The requirements for implementation of CEP on GDOT projects*

# Recently Posted!

**Tuesday, July 20**

**Joint Coordination Procedures: Streamlining Consultation with FHWA and US Fish & Wildlife Service**

Chris Goodson, Ecology Section Manager

- *How and when GDOT coordinated with federal and state agencies*
- *Opportunities for environmental process streamlining and schedule recovery*
- *Current and future incentives for prioritizing ecological design*
- *Which design changes do and do not require reinitiating agency consultations*

**Ecology Post-Construction Stormwater Report**

Dave Hedeen, Ecology Section Manager
Brad McManus, PE, State Roadway Hydraulics Engineer
Sarah Jones, EIT, Water Resources Engineer

- *The purpose, applicability and contents of the Ecology Post-Construction Stormwater Report template*
- *Common water quality terminology*
- *Reasons to build a post-construction BMP*
- *Reasons to not build a post-construction BMP*

# Posting Soon!

**Wednesday, July 28**

**Perennial Stream Culvert Requirements:  Design and Delivery Strategies**

Sam Woods, PE, Assistant State Roadway Design Engineer

David Hedeen, Ecology Section Manager

*Following attendance at this session, project managers, designers and environmental staff will understand:*

- *USACE's Regional Conditions on perennial stream culverts*
- *The concept of bankfull width:  definition, methodology, importance/relevance to design*
- *How to design a culvert that complies with the Regional Conditions*
- *How to address perennial stream culvert requirements, including diagrams, in Section 404 permit applications*
- *Project delivery implications for projects with perennial stream culverts*

# QUESTIONS?


**Dave Hedeen**

**Georgia Department of Transportation**

Ecology Section Manager

dhedeen@dot.ga.gov

**Sam Woods**

**Georgia Department of Transportation**

Asst. State Roadway Engineer

swoods@dot.ga.gov

## Follow-up and Thank you

- Request PDH certificate by Friday July 30$^{th}$

- Many thanks to Brian Stocks, producer

- Special acknowledgement:
  - Christina Schmidt, Atkins Ecology